POWER

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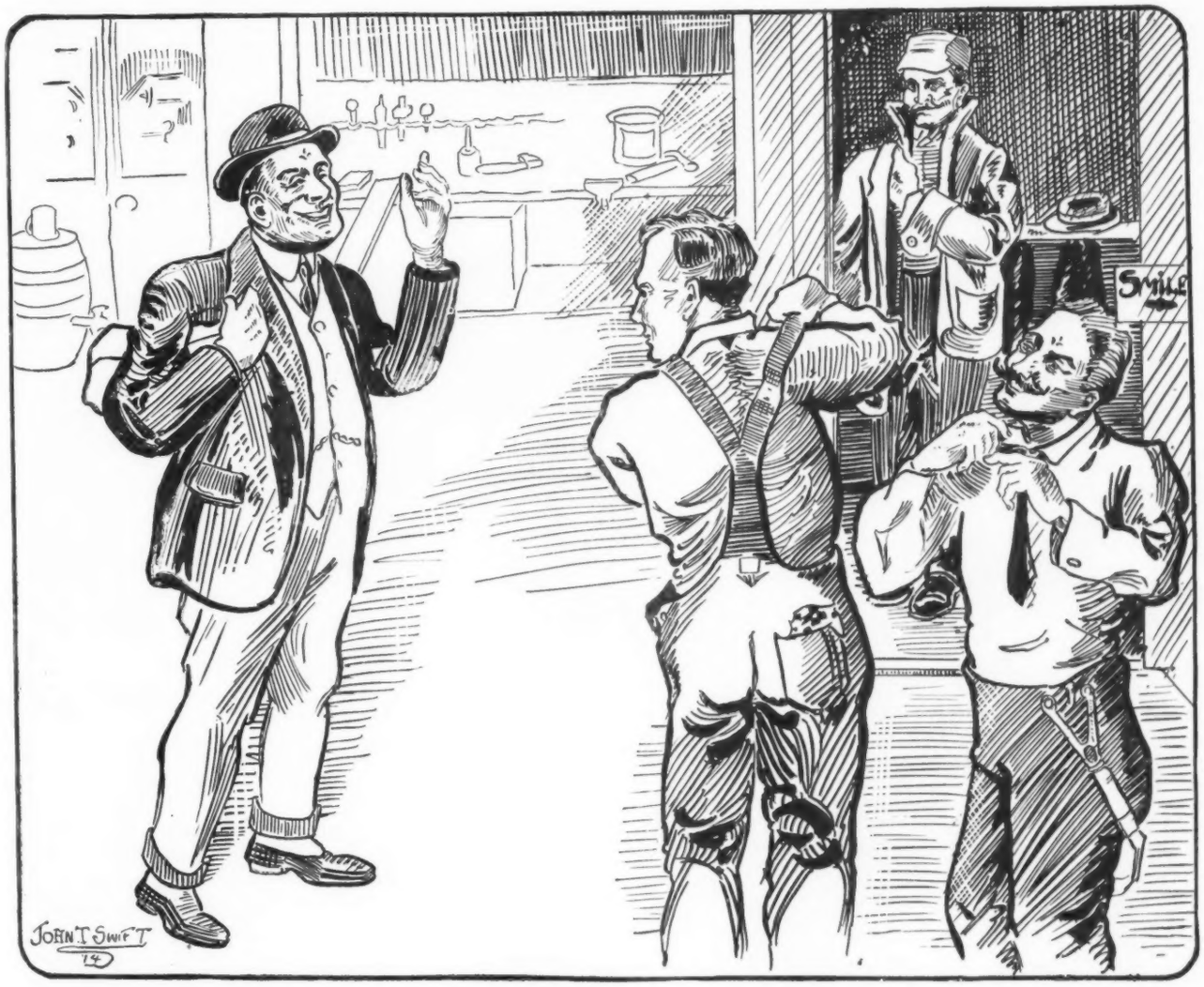
"A Merry Christmas Face"



HAVE YOU a vinegar aspect? Do you carry an ingrown GROUCH to work? Forget it. The world hates a "gloom"—a "gloom" hates himself. A smile's worth while. Everyone loves a LAUGHER. Switch sixty-four candle power into your face. Light up with peeping eyes and a good, big, broad grin. Put more of comradeship, of CHEER into that "Good morning, Bill," "Howdy, Jack," "Top o' th' morn, Steve," at the plant tomorrow. A cracker-jack little EFFICIENCY ENGINEER, that old SMILE of yours. Give "him" a tryout and he'll make GOOD. Ever think about it that way?

[Contributed by John T. Swift, Denver, Colo.]

A Detroit Flour-Mill Plant

By Thomas Wilson

SYNOPSIS—This is a 600-kw., single-unit turbine plant carrying a connected motor load of 1080 hp. and 25 kw. in lamps twenty-four hours a day and six days a week. The operating cost per kilowatt-hour is 0.48c.

The Commercial Milling Co., Detroit, Mich., has one of the best equipped flour mills in the country, its capacity enabling it to produce 1200 bbl. per day of the Henkel products. In the near future the capacity will be doubled.

The machinery in all departments is of the latest design and for the most part is belt driven from line shafts turned by motors. To the shaft driving the complete series of rolls a 300-hp. motor is connected by a rope drive; a 200-hp. motor drives all of the bolters and purifiers; a 125-hp. motor elevates 10,000 bu. of grain per hour from the basement to the top of the building where it flows to the bins by gravity; a 50-hp. motor operates the marine leg for unloading wheat from the boats; a 35-hp. motor operates an Otis freight elevator, and other motors of 15 hp. and less drive other machinery and elevators in the new mill. In the older mill there are four motors rated at 125, 100, 50 and 10 hp. Fig. 3 shows one of the large motor drives.

All of these motors, totaling 1080 hp., are of the three-phase induction type. For the lighting there are a thousand 25-watt Mazda lamps. The total load runs from 800 to 1050 amp., the current being 903 amp. at normal rating and the voltage 480, for which all of the motors are wound. For twelve months this load has been carried night and day, with the exception of Sundays, by one 600-kw. (at 80 per cent. power factor) generating unit (Fig. 1) consisting of a four-stage, impulse, horizontal turbine coupled to a three-phase generator revolving at 3600 r.p.m. There has been no occasion to shut down for repairs. In case of such a necessity, the mill would come to a standstill as there is no reserve unit of sufficient capacity nor a breakdown connection to keep it running. Sundays and a surplus stock in the mill are relied on to tide over a breakdown. Eventually, a new mill of the same size and another turbine unit will be erected.

A surface condenser containing 1400 sq.ft. of cooling surface maintains a vacuum of from 28 to 28.5 in. on the main unit. Circulating water is drawn from a cold well open to the river by a turbine-driven centrifugal pump.

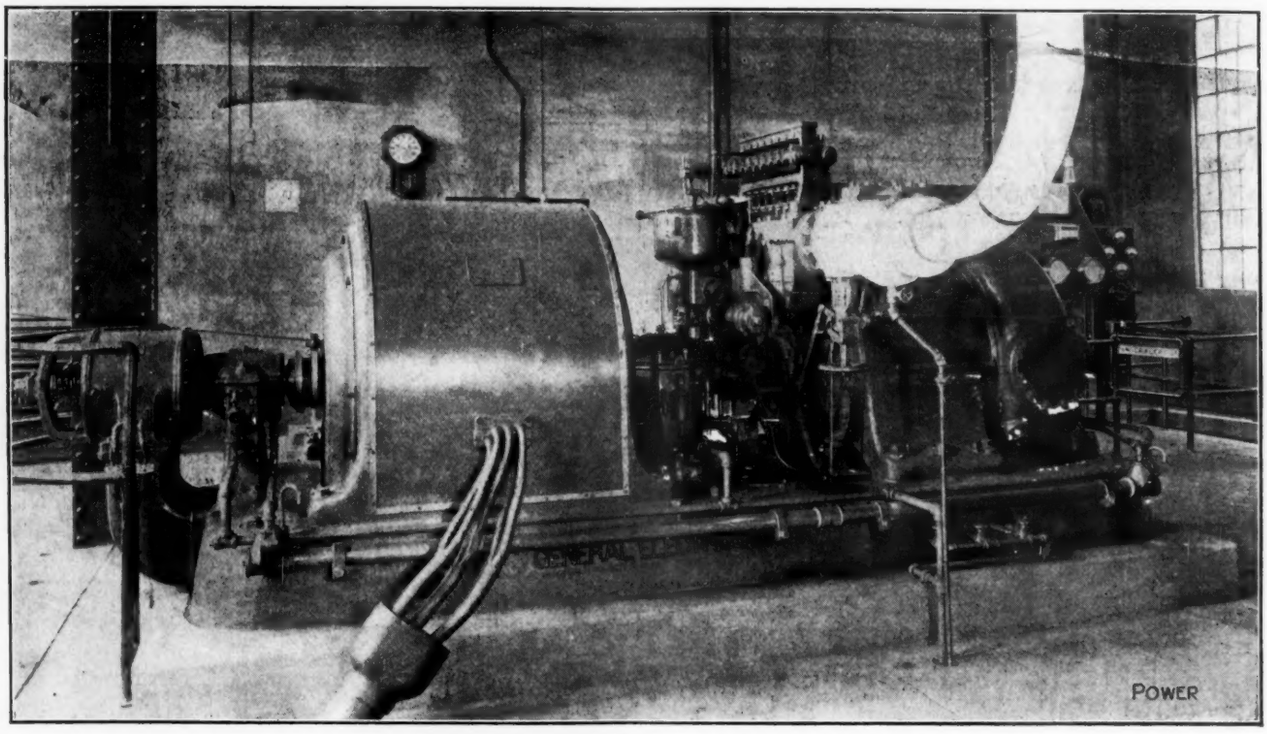


Fig. 1. Main 600-Kw. Generating Unit

The condenser is protected by a three-unit strainer, Fig. 2, placed on the discharge side of the pump because of lack of room on the suction side. The water is discharged to a hotwell and flows back to the river by gravity. On the same shaft and driven by the same turbine, another small centrifugal pump delivers the condensate to a 1250-hp. open heater in the boiler room, where its temperature is raised to 212 deg. The condenser and the two pumps just mentioned are in the basement, but the 6 and 14 by 10-in. dry-vacuum pump has been placed on the engine-room floor.

To light a large sign on top of the building on Sunday night or at other times when the main unit might be shut down, there is a two-cylinder, 9x11-in. gas engine (Fig. 4) using city gas. This engine is belt connected to a 60-kv.-a., 480-volt, three-phase generator. Of course, this unit may be used to carry a small part of the mill load. Recently it has been planned to throw the generator on the line and run it unloaded as a synchronous motor, the

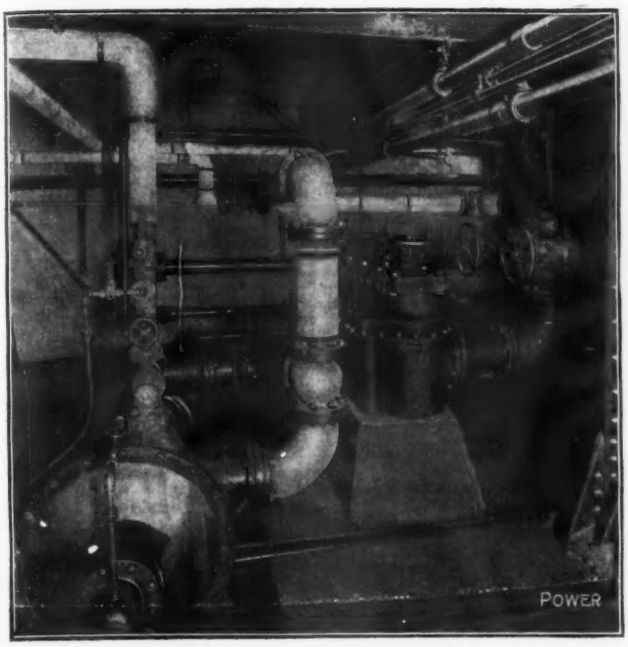


FIG. 2. CONNECTION OF THE THREE-BASKET, 12-IN. STRAINER

underneath it is an auxiliary header for the pumps. The layout is shown in Fig. 7.

There are two feed pumps of the duplex center-packed type and two single-cylinder pumps which draw water from the hotwell and deliver it to the heater in case of failure of the city supply, which is the usual source of makeup water. These pumps, the condenser auxiliaries and the stoker and fan engines give enough exhaust steam to heat the feed water and supply the heating system in moderate weather. The heating system is of the two-pipe gravity type, from which the condensation is drained to a receiving tank and returned to the heater. In the colder months some live steam reduced to 1 lb. pressure is required for heating, and also a small amount for the wheat heater.

Meadow Brook bituminous coal is delivered on a railway siding near the boiler room and motor-operated capstans switch the cars to the location for unloading. The coal is dumped into a hopper and carried by a belt to a bucket conveyor which raises it to the top of the boiler room and drops it into a screw conveyor provided with sliding doors in front of each bunker; there are four in all, with a total capacity of 300 tons. From the bunkers the coal is temporarily shoveled into the stoker hoppers, but this arrangement is to be superseded by concrete bins

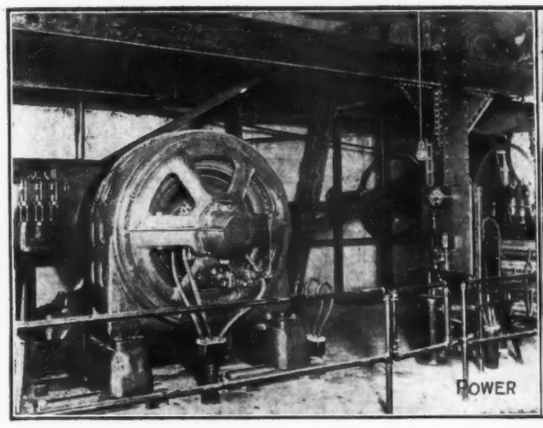


FIG. 3. ONE OF THE LARGE MOTOR DRIVES

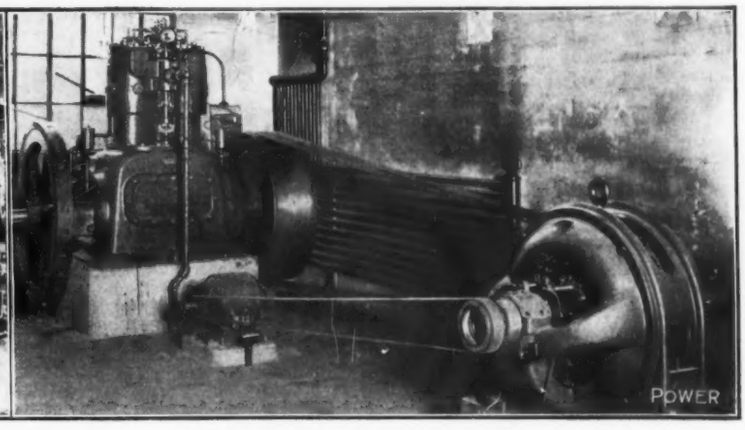


FIG. 4. GAS-ENGINE UNIT

object being to counteract the lagging current caused by the induction motors and thereby improve the power factor.

A standard switchboard (Fig. 5) equipped with the usual instruments serves the generator and feeder circuits, and there is an independent panel for the gas-engine unit. There are the usual ammeters and voltmeters, a Tirrell voltage regulator and four recording meters, for the generator, the motors in the old mill, the 200- and 300-hp. motors in the new mill and a fourth for all of the others. Besides there are gages for recording the boiler pressure and the vacuum.

At present the boiler room (Fig. 6) is equipped with two 350-hp. water-tube boilers, and a third will be installed when additional turbine capacity requires it. The working pressure is 185 lb. and superheaters raise the steam temperature 110 deg. above that corresponding to the pressure. At the turbine the pressure is 175 lb. The boilers are eqripped with underfeed stokers which require forced draft, a breeching with one right-angle turn and a 150-ft. brick stack 6 ft. in diameter at the top. The header for the main unit is back of the breeching and

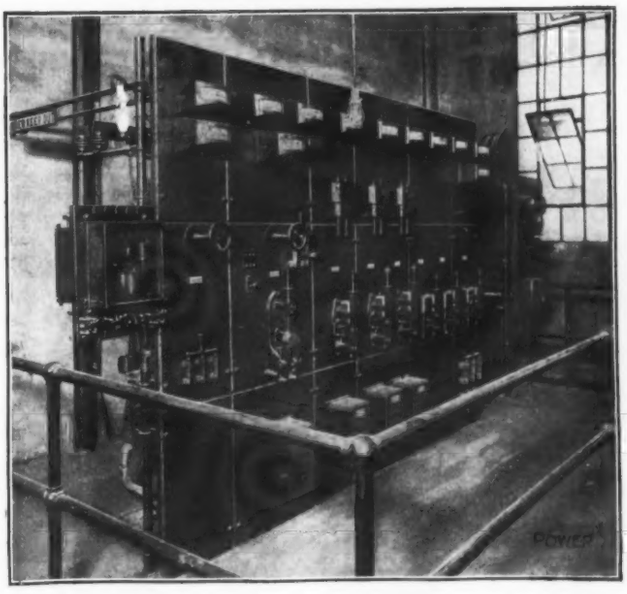


FIG. 5. SWITCHBOARD AND GAS-ENGINE PANEL

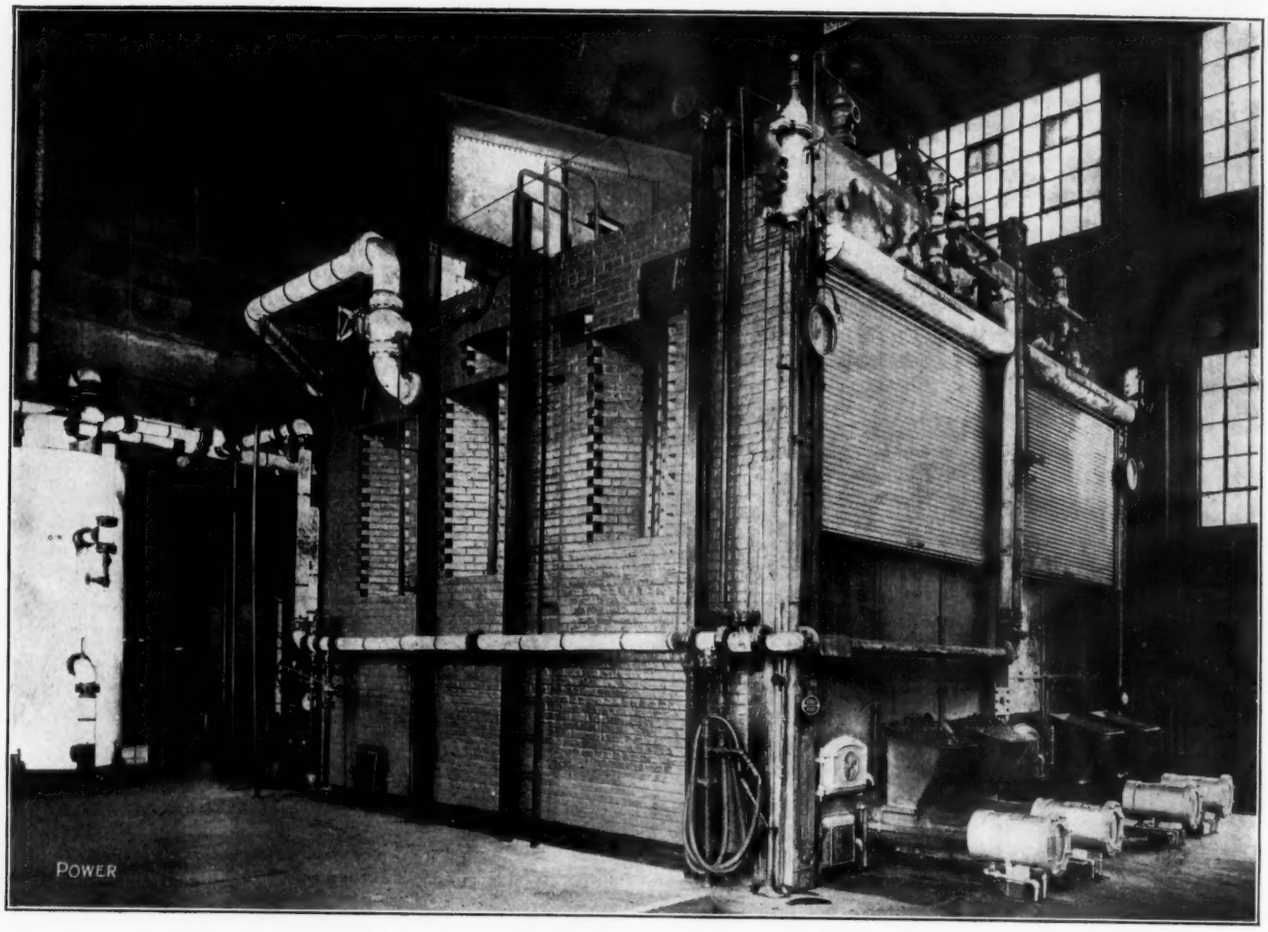


FIG. 6. TWO BOILERS, WITH SPACE FOR ANOTHER UNIT

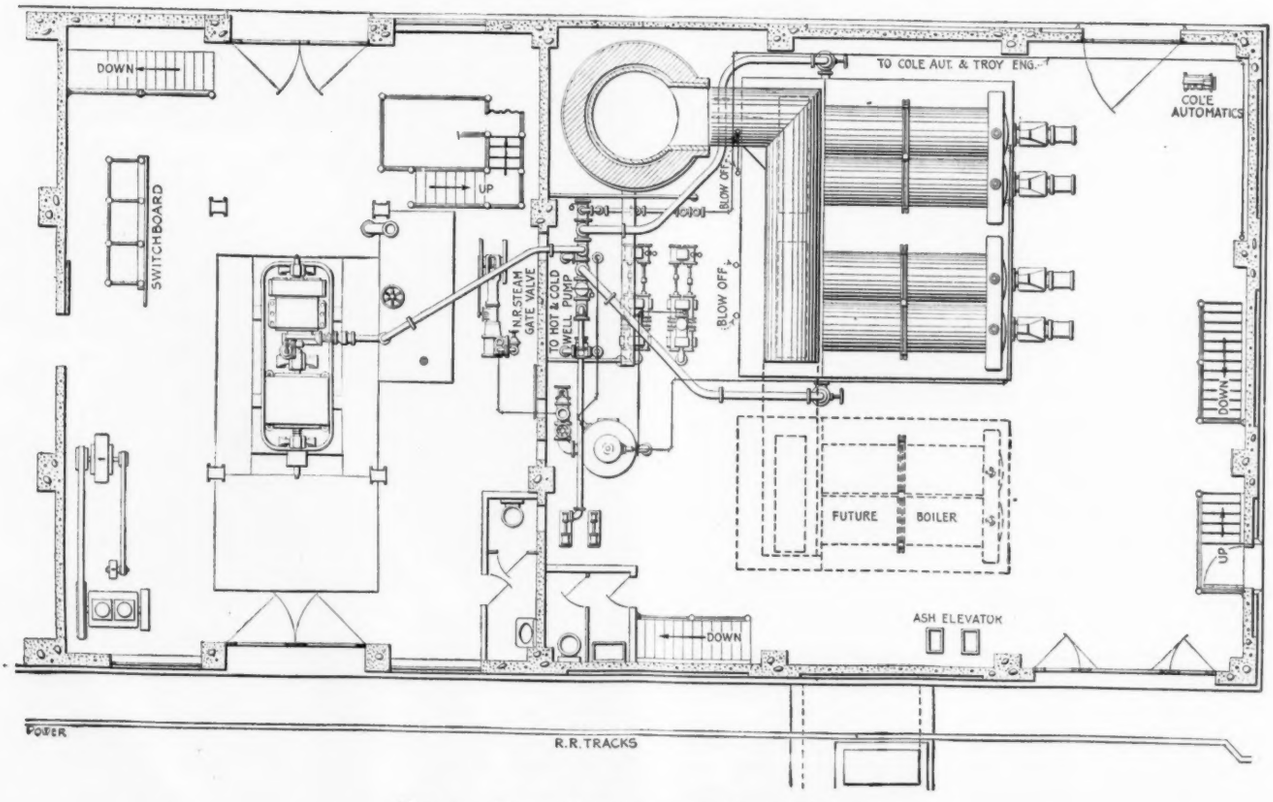


FIG. 7. PLAN VIEW OF THE POWER PLANT

so raised that the chutes will feed through scales into the stoker hoppers.

Unit Costs

The equivalent of a three-story building houses the power plant and the large motor drives. Its approximate cost was $10,000. The equipment and its installation, exclusive of the gas-engine unit, cost close to $45,000, and 970 hp. in new motors and control equipment cost $13,000. Including the last item, which really does not belong to the power plant proper, the cost per kilowatt of rating amounts to

$$\$68{,}000 \div 600 = \$113.$$

Without the motors the unit cost is reduced to approximately $92 per kilowatt, and for the power-plant equipment and its installation only, the cost per kilowatt is $75. Including the permanent coal bunkers will increase this figure slightly, but by the time another boiler and a second turbine of the same capacity have been installed in the spaces reserved for them, the cost per unit will be lower. At present the turbine capacity is 600 kw. and that of the two boilers is 700 hp., a ratio of 6 to 7, or 1⅙ boiler-hp. per kilowatt of rating. With the plant increased to three boilers and two turbines, the ratio will be 12 to 10.5, or 0.875 boiler-hp. per kilowatt of generating capacity. At present, one boiler carries the load.

River water is available for the surface condenser. The 1400 sq.ft. of cooling surface means 2⅓ sq.ft. per kilowatt of rating and that at normal load each square foot must condense about 6 lb. of steam per hour.

Five men operate the plant and take care of all the motors in the mill. The annual labor bill is $4770, made up as given in Table 1.

TABLE 1. ANNUAL WAGE OF EMPLOYEES

One chief engineer	$1200
One night engineer	1014
Two firemen	1620
One electrician	936
	$4770

For oil and supplies, including some minor repairs, $250 was expended during the year. This item will, of course, be larger as the plant ages. Records of coal consumption and electrical output are available only for July, August and September. Table 2 gives the totals for each month and the weight of coal per kilowatt hour.

TABLE 2. COAL CONSUMPTION AND ELECTRICAL OUTPUT

	July	August	September
Coal, pounds	486,000	626,680	779,120
Kilowatt-hours	182,560	253,620	253,250
Coal, pound per kilowatt-hours	2.66	2.47	3.08

For the three months the coal, per kilowatt-hour averaged 2.74 lb., costing $2.20 per short ton. During the quarter the 945.9 tons consumed cost $2080.98. In the same period the labor item would amount to $1192.50 and the supplies to $62.50. The total operating cost for the three months would then be

$$\$2080.98 + \$1192.50 + \$62.50 = \$3335.98.$$

Dividing by the total output gives an operating charge per kilowatt-hour of 0.48c. To this a fixed charge of 12 per cent. on the investment—made up by 5 per cent. depreciation, 5 per cent. interest and 2 per cent. insurance and taxes—should be added. For the quarter, 12 per cent. of $55,000 amounts to $1650 and per kilowatt-hour of output to approximately 0.24c. Adding the operating and fixed charges gives a total of $0.72c. per kw.-hr.

For a plant of 600-kw. capacity the cost per unit output is so low as to leave room for reasonable doubt as to the accuracy of the records. It must be remembered, however, that one turbine is running day and night under an economical load and high vacuum, that there is no reserve unit to increase the overhead expense; that few supplies were purchased, and the repairs on a new plant are naturally a minimum. For the service rendered the labor item is also low. It will be of interest to check these figures when operating data over a longer period are available.

PRINCIPAL EQUIPMENT OF COMMERCIAL MILLING CO. PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Turbine	Horizontal impulse	600 kw.	Main generating unit	175 lb. gage, vacuum 28¼ in., 3600 r.p.m.	General Electric Co.
1	Generator	Alternating current	600 kw.	Main unit	Three-phase, 480 volts, 3600 r.p.m.	General Electric Co.
1	Condenser	Surface "Speroflow"	1400 sq.ft.	Serves main unit	River water, vacuum 28¼ in.	Alberger Pump & Condenser Co.
1	Pump	Centrifugal	8-in.	Condenser circulating water	Driven by 30-hp. Alberger turbine	Alberger Pump & Condenser Co.
1	Pump	Standard volute	2-in.	Condensate pump	Driven by same turbine as circ. pump	Alberger Pump & Condenser Co.
1	Pump	Reciprocating	6x14x10-in.	Dry vacuum pump	175 lb. steam, exh. to heater	Alberger Pump & Condenser Co
1	Gas engine	Vertical, 2 cycle	9x11-in.	Light large sign	Belted to 60-kw. G. E. generator	Westinghouse Machine Co.
1	Multiple strainer	Three-basket	12-in.	Strain condenser cooling water	Located between pump and condenser	Lagonda Mfg. Co.
2	Boilers	Water tube	350 hp.	Generate steam	185 lb. steam, stokers, forced draft	Edge Moore Iron Co.
2	Stokers	Jones under feed		Serve boilers		The Under Feed Stoker Co. of America
2	Superheaters	Foster		On 350-hp. boilers	110 deg. superheat	Power Specialty Co.
1	Heater	Open	1200 hp.	Heat feed water	Exhaust from pump and aux.	Perfection Heater & Purifier Co
2	Pumps	Duplex	10x6x12-in.	Boiler feed water	185 lb. steam	Dean Bros. Steam Pump Works
2	Pumps	Simplex	8x7x12-in.	Pump from hotwell to heater	185 lb. steam	Dean Bros. Steam Pump Works

Switchboard and all motors furnished by the General Electric Co. Rope drivens by Hill Clutch Co.

Pocket Calculator

The small pocket calculator shown is an ordinary 6-in. logarithmic slide-rule, put into circular form for compactness. It consists of a circular base plate carrying continuous scales on its periphery and lower face; a movable top plate, or rotor, arranged to turn on the hub of the first member and carrying similar scales on its periphery and upper face; a slotted hub nut to keep the rotor in place and adjust the friction thereof and a slider, or runner, with cross-hair and pointers, to be used in conjunction with the first two members.

Circular Pocket Calculator

Shrunk upon the outer circumferential rims of the base plate and movable top plate, and protected by their flanges, are two mechanically divided scales of white, seamless celluloid. Set into sunken panels in the bottom of the base plate and top of the top plate, are flat, hard, white-enamel annular dials, upon a copper diaphragm.

The runner is a bent metal frame carrying a transparent celluloid window. This frame embraces the edges and outer portions of the calculator, and by two pairs of feet, each pair running in a groove, in the top and bottom of the main instrument, is constrained to travel in a circular path; or if the runner be held in a fixed position, the instrument, with all its scales, may be rotated beneath it.

A variety of calculations can be accomplished with this instrument. It is made in several models for different classes of work by Small, Small & Co., Waltham, Mass.

Modern Lightning Arresters

By Charles C. Raitt

SYNOPSIS—The functions of a lightning arrester, the principal types and their methods of operation.

The successful lightning arrester must serve the line which it is intended to protect in the following manner:

First, it must immediately relieve the line of any excessive strain whenever called upon to do so.

Second, it must not allow the normal line current to leak to ground, either before discharging or for any appreciable length of time after discharging.

Third, it must recover quickly after discharging and be ready to operate repeatedly.

Fourth, it must be capable of performing these duties without injury to itself.

Multi-Gap

The multi-gap type of arrester represents probably the largest group and is used for the greatest variety of voltages. The telephone arrester shown in Fig. 1 may be considered as the elementary form of this type. The normal telephone current passes into the line binding post *L*, through the fuse *F*, and out the binding post *P*, which is separated from ground by a perforated strip of mica *M*, held between two carbon blocks *C* and C_1. Lightning discharges break down the short gaps between the carbon blocks and flow to ground rather than take the inductive path through the telephone.

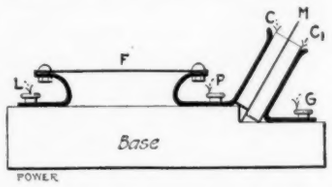


Fig 1. Telephone Type of Arrester

This arrangement has been improved upon by using a gap inclosed in a metal tube and surrounded by special gases which will give the desired potential to the gap. It is claimed that this type is particularly strong and reliable and gives good cooling surfaces.

Arresters for voltages up to approximately 1000 have several short gaps in series between the line and ground, a common form using a number of knurled cylinders placed on end and so spaced that, when discharging, the arcs form between the knurled surfaces. An arrester of this type is shown in Fig. 2, arranged for 300-volt service. The cylinders are usually made of nonarcing metal, the vapor tending to kill the arc. It is essential that the arc shall be broken as soon as the strain on the line is relieved, otherwise the line current would follow the discharge to ground. The action of the nonarcing metal is in the nature of a rectifying effect, as the vapor from the arc will conduct the current in only one direction. Hence when the current reverses, the vapors have a chance to cool below the arcing temperature before the current again attempts to pass. For this reason arcs caused by a high-voltage discharge tend to die out at the first reversal of current after the discharge has ceased.

Some manufacturers use a resistance in series with the gaps to reduce the dynamic current which flows to ground after the gaps have been bridged by a discharge.

The General Electric Co. recommends a multi-gap arrester with graded-shunt resistances placed as shown diagrammatically in Fig. 3. For line voltages of 5700 to 37,000 and with slight modifications for lower voltages, the action of this arrester is as follows:

Graded-Shunt Resistance

When a high-potential disturbance occurs it takes the path through the high resistance and breaks down the gaps at the lower end of the row, thus passing to ground. If the current thus discharged is heavy, the drop in potential across the resistance may be sufficient to break down the gaps between the high and the medium resistance. In this case, the discharge will take the medium-resistance path. A still heavier current may cause it to jump the next group of gaps and take the low-resistance path. A very extreme case might cause the discharge to desert the resistances entirely and jump the whole line of gaps. As the disturbance subsided and the current died down, the discharge would reverse its program, preferring the shunt resistance to the group of gaps in each step until it was again flowing through the high resistance. Normal line voltage would not be able to maintain an appreciable current through this high resistance and therefore the arc would die out. This principle is superior to that of a resistance in series with the gaps, because in this case the resistances are out of the circuit while a heavy discharge is passing the arrester. Fig. 4 shows a 2200-volt arrester of this type discharging and shunting the current.

A different form of multi-gap arrester is shown in Fig. 5, which is a Westinghouse type, designed for 6600-volt circuits. The gaps occur between the metal pans or caps, mounted on an insulating rod. Below the gaps is a resistance rod, which is in series with the gaps and the ground. The outdoor type has a hood to protect the gaps from rain and snow, when on poles without being boxed.

Circuit-Breaker Type

The circuit-breaker arrester is primarily a multi-gap type, provided with an arrangement for mechanically breaking the path to ground whenever the line current begins to follow the discharge. Fig. 6 shows a 2500-volt Garton-Daniels arrester of this type. The discharge takes the straight-line path, on the right-hand side of the illus-

tration, entering the line binding post at the top, jumping the two upper gaps, passing through the resistance rod in the center and then jumping the two lower gaps to the ground binding post. An inductive shunt circuit is provided by connecting one end of the plunger-magnet coil on the left to the lower end of the resistance rod, the other end of the coil is connected to the upper end of the plunger, and the lower end of the plunger rests on a brass

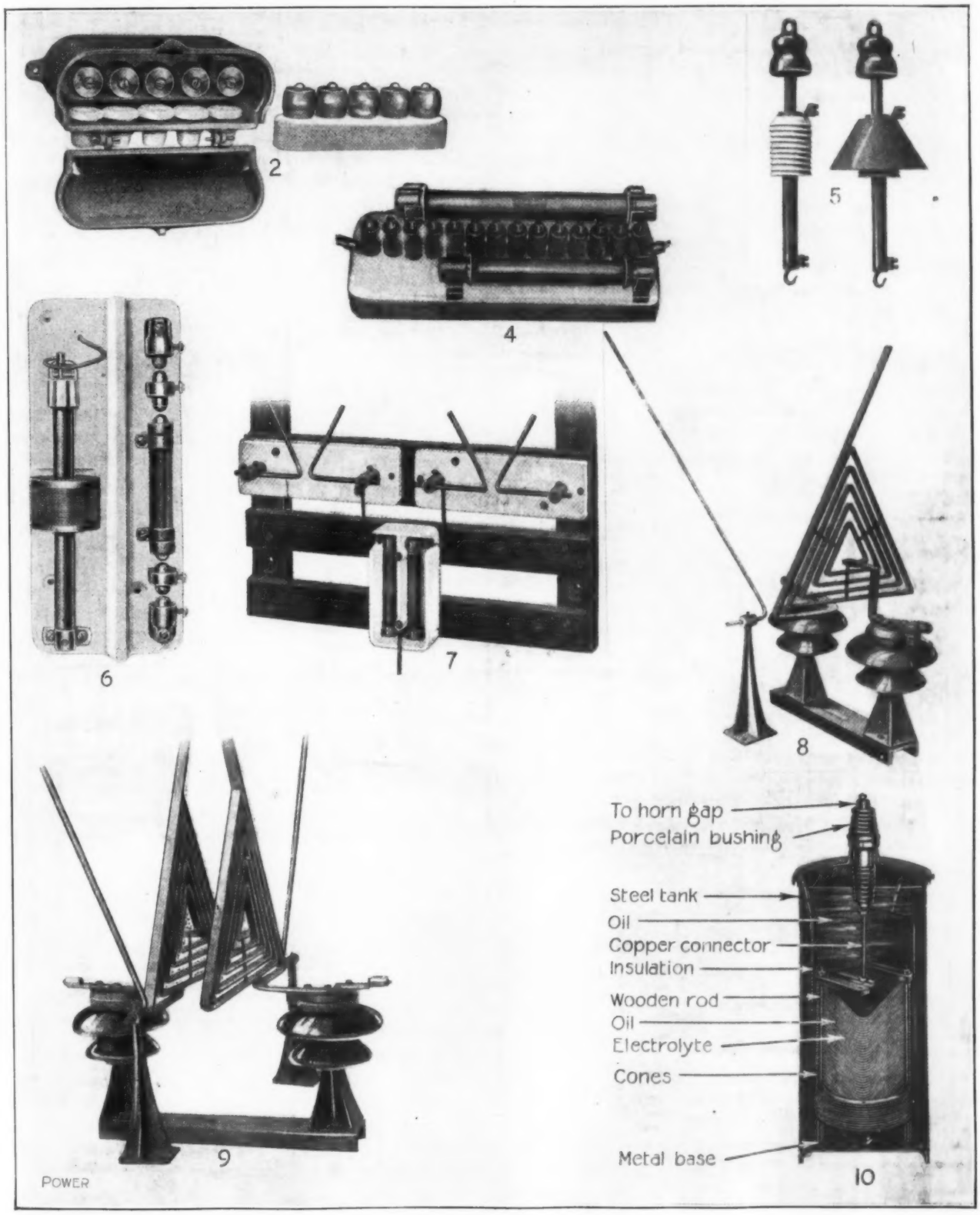


FIG. 2. MULTI-GAP ARRESTER FOR 300 VOLTS. FIG. 4. GRADED-SHUNT ARRESTER FOR 2200 VOLTS, DISCHARGING. FIG. 5. INDOOR AND OUTDOOR TYPES. FIG. 6. GARTON-DANIELS TYPE. FIG. 7. HORN-GAP TYPE, MOUNTED FOR SERIES ARC CIRCUIT. FIG. 8. BURKE ARRESTER—SINGLE GAP. FIG. 9. BURKE ARRESTER—DOUBLE TYPE. FIG. 10. ALUMINUM-CELL ARRESTER

button connected to ground. If the line current continues to flow after the disturbance has subsided it will take the inductive path through the plunger magnet rather than jump the two lower gaps, because of its low frequency. Current flowing in the coil will actuate the magnet and the plunger will open the path to ground. As soon as the arc is broken the current ceases to flow and the plunger falls back by gravity, leaving the arrester ready to operate again. The manufacturers claim for this arrester that the circuit-breaker allows the use of a smaller series resistance and fewer gaps in the path to ground, and also that it provides a positive mechanical break to prevent the line current from following the discharge to ground. It is open, however, to the criticism that any device depending on moving parts for its operation is more easily crippled than one which has none.

Horn Gap

A familiar type of lightning arrester is the horn gap, a simple installation, intended for use on series arc circuits, being shown in Fig. 7. One gap and a series resistance are inserted between each line and the ground. When a discharge has passed to ground the arc rises on the horns due to the rising column of hot gases and thus, reaching a length of gap which cannot be maintained, extinguishes itself. Choke coils are frequently placed in series with the line when horn gaps are used. The high-frequency lightning discharge avoids the choke coil and is more certain to take the path to ground.

Fig. 8 shows the Burke arrester, a combination of horn gap and choke coil in one piece. The horn on the right is one side of a triangular coil wound from strip copper and spaced with fiber blocks. The coil is placed at right angles to the line and in series with it. The ground horn is shown on the left, mounted on a separate holder. A surge or discharge entering from the rear first takes a gradual turn toward the left side and then a sharp turn up. Opposite this sharp turn, where the potential strain is concentrated, is placed the ground horn. Just beyond this point is the choke coil which also provides a magnetic blowout effect which hastens the extinguishing of the arc as it rises on the horns. A single unit of this type will only protect the line in one direction, but it is suitable for use where a line enters a building. A double arrester, providing protection in both directions, is shown in Fig. 9.

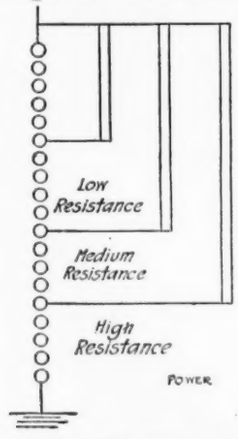


Fig. 3. Resistances in Graded-Shunt Type

Electrolytic Type*

The electrolytic lightning arrester is now being used almost exclusively for very high potential circuits and extensively for medium voltages. It seems to be the ideal protection for station equipment, where it can be properly cared for and where there is a concentration of expensive equipment to be protected. This arrester consists of a stack of cone-shaped aluminum plates spaced about 0.3 in. apart, the spaces between the plates being filled with an electrolyte; the whole stack is immersed in a tank of oil. The oil keeps the electrolyte from evaporating and prevents a too rapid rise of temperature during discharge. Fig. 10 shows a section of an aluminum arrester of this type. The principle of the cell is briefly as follows:

The bottom plate is connected to ground, and the top plate to a horn gap, which may be closed when desired to complete the path to ground. After a cell has been installed, it is charged by closing the horn gap through a resistance. A current then passes to ground through the electrolyte and causes a film of aluminum hydroxide to form on the aluminum plates. As the film grows thicker it offers more and more resistance to the current until finally only a slight current will pass. The cell is then ready for use. The film which has been formed has a critical voltage and when that voltage is exceeded the cell will discharge large currents for short periods without harm to itself. The horn gap is set large enough to prevent a leakage current from passing constantly through the cell, but not large enough to interfere with the operation of the arrester. This type of arrester is very effective in relieving the line of surges as well as from lightning discharges. The cell must be charged about once a day because the film dissolves gradually when the cell is idle.

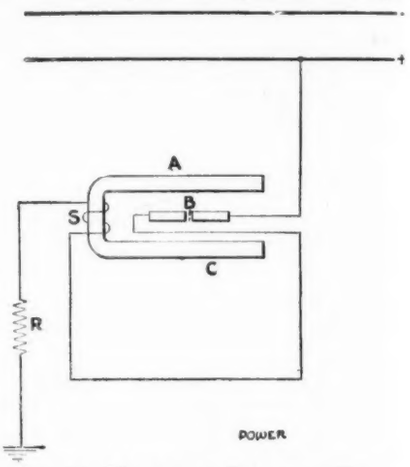


Fig. 11. Magnetic Blowout Type for Direct Current

When used on a three-phase circuit with grounded neutral, three cells may be used and connected to a common ground; an arrangement which gives two cells between each two phases. In case of a fallen line there will be a dead short-circuit on one phase, the circuit-breakers will open that phase and there will be no danger of destroying the cell. When used with a three-phase circuit without the grounded neutral it is necessary to provide a fourth cell between the common ground wire of the other three cells and the actual ground. When this system is used and a line falls there will still be two cells between each two phases. This arrangement is also used with other single-pole arresters on three-phase lines.

Arresters for Direct-Current Circuits

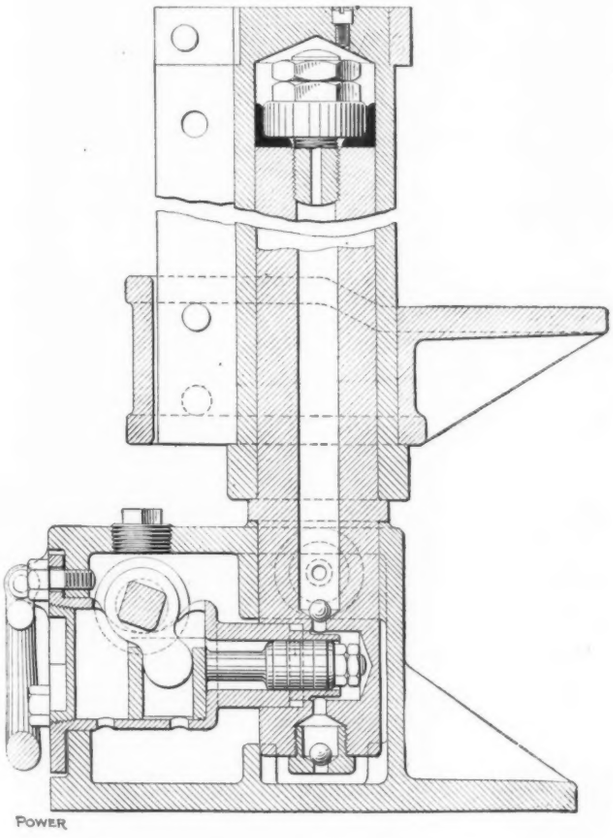
An arrester which is commonly used in railway work and is well adapted to low-voltage, direct-current apparatus, is shown in Fig. 11. It consists of a spark gap B placed between the two poles of a magnet A-C. A discharge in passing to ground jumps the gap, passes through the coil S and the resistance R to ground. When the line current attempts to follow the discharge across the arc it produces a magnetic field in the coil S, which flows from A to C, and draws the arc out of its course, causing it to become so long as to cool and break. This is familiarly known as the magnetic-blowout type of arrester.

*For a more detailed description of this type see "Power," Sept. 9, 1913.

Emergency Hydraulic Jack

A type of hydraulic jack embodying new features is illustrated herewith. The claw can be moved vertically and adjusted to a convenient height. With the cylinder, the claw can be swung in a circle without changing the position of the jack body or of the pump lever. The cylinder is the moving part of the jack instead of the ram, which allows the pump mechanism to stay in a fixed vertical position.

The piston is packed with leather rings; ball valves are used and there are ample oil passages. The oil, besides acting as a lubricant, prevents rusting of the working parts and the possibility of freezing, and it has no



SECTION THROUGH HYDRAULIC JACK

detrimental effect on the packing. The oil pressure is released by a key operating a small needle valve.

The 18-in. operating lever is curved. The socket has a hole in each of its four sides to allow convenient operation from various positions.

This jack, manufactured by the Watson-Stillman Co., New York City, is built in 5- and 10-ton sizes, with a ram stroke of 10 in., and is guaranteed to withstand a 50 per cent. overload.

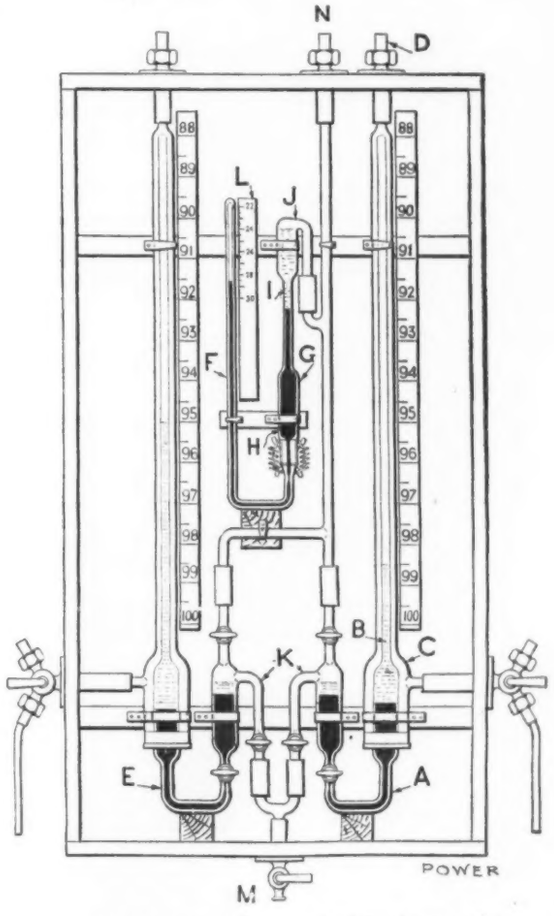
Damage to Feed-Water Heaters—If the float valve at the feed-water heater sticks, it should not be raised by the engineer in order to admit water which is at city pressure. This pressure may cause the heater to burst through the failure of the overflow trap to quickly relieve it. Occasionally a heater is damaged by an engineer who, in an attempt to heat the water in the heater, will so manipulate a trap that the steam in the high pressure drips will blow directly through it and into the heater.

New Condenser Gage

A new gage for use with steam condensers, the Scanes vacuum efficiency and absolute pressure gage, has recently been developed. The device is designed to show if the condenser is dirty; if too little cooling water is being used; if there is an excess of air in the system; if the cooling water is too hot; if power is being wasted by pumping too much cooling water, or whether the air pump is in good condition. The gage is for constant use with the condenser, and not only denotes the true vacuum and whether it is varying, but also indicates the causes of the changes.

When the gage is used with a surface condenser it reads the absolute pressure, or vacuum corrected to a 30-in. barometer; the vacuum efficiency, i.e., the percentage of the theoretical vacuum due to the condensed steam temperature which is being maintained in the condenser, and also the condenser efficiency, or the percentage of the theoretical vacuum due to the cooling-water discharge temperature.

When used with a jet condenser, the second and third readings are the same.



GAGE FOR SURFACE CONDENSER

The glass U-tube *A* (see illustration) is sealed at one end, exhausted of air and then filled with colored water *B*, which is heated to the temperature of the condensed steam by a small jet of the latter, drawn through the outer tube *C* through the connection *D* to some convenient point of vacuum. The water in the inner tube *A* then takes such a position that the vapor pressure in the tube and the column of water in that leg will bal-

ance the vacuum in the condenser and the column of water in the other leg; the difference of level of the colored water in the two legs is a measure of the vacuum efficiency of the condenser, as the colored water is at the temperature of the condensed steam.

The pipe *N* is connected to the vacuum to be tested. The left U-tube *E* in a similar manner reads the condenser efficiency, a small stream of the discharge cooling water being passed through the outer tube. The mercury in the bottom of the U-tube is to prevent air passing into the sealed side.

For a jet condenser but one U-tube is used.

The mercury U-tube *F* is an improved absolute pressure gage for indicating the vacuum in the condenser, corrected to a 30-in. barometer. No chemicals are used and water condensing on the mercury does not affect the reading. The left side of the U-tube is sealed and exhausted to as perfect a vacuum as is possible, the tube is filled with mercury and the other end is closed by a thin rubber sack, inclosed in a glass bulb and is filled with mercury.

The pressure in the condenser is transmitted to the mercury in the bulb *G*, and then through the rubber sack *H* to the mercury in the sealed leg. The difference of level of the mercury in the two legs is a measure of the vacuum in the condenser. The rubber sack is only partially filled with mercury and is not in tension, and does not affect the reading. The bulb *G* is continued into a narrow tube, which is again enlarged at *I* to form a second bulb *J*, which is filled with water to the overflow *K*; the scale *L* is corrected for the weight of water on the mercury, and any further water which condenses in *J*, overflows, and can be blown back into the condenser by opening the cock *M*.

Examples of the use of the gage are as follows: A vacuum in *F* of 28 in., with a vacuum efficiency of 98.5 per cent., and a condenser efficiency of 98 per cent., shows that the efficiencies are normal, and the vacuum is as good as may be expected without more cooling water. If the vacuum drops to 27 in., the efficiencies are as before, but either more water is needed, the inlet temperature has gone up, or the condenser is overloaded. If the vacuum is 27 in., with a vacuum efficiency of 98.6 per cent. and a condenser efficiency of 94 per cent., the condenser needs cleaning. In another case, with a vacuum of 27 in., and both efficiencies worse, there is probably an air leakage; alternatively, the air pump is in bad condition, or in the case of a rotary air pump the seal water is too hot.

As a further example, suppose the engineer is not satisfied with a vacuum of 28 in., and increases the circulating-water quantity, without result, he will probably see that although the vacuum is still 28 in., the efficiencies have fallen off. This would show that the air pump is not capable of more than 28 in., with the existing air leakage, and he must either reduce this or increase the capacity of his air pump. If, however, only the condenser efficiency had fallen (with the condenser clean), and the vacuum efficiency had remained at 98.5 per cent., it would prove that the size of the condenser would not allow of a higher vacuum.

Equipment and Methods in Largest Refrigeration System--III

By Charles H. Bromley

SYNOPSIS—Further description of the 1000-ton ammonia compressor of the Quincy Market Cold Storage & Warehouse Co., Boston. A governor driven through automobile transmission gears, with other features, allows flexible adjustment. A synchronous motor-driven tachometer indicates the speed, and a crank index helps the operator in starting and stopping the compressor. A quick-closing throttle with electric and steam control is also a feature. Lubrication system for the compressor which handles two widely different suction pressures in the same cylinders.

An Interesting Governor

Wide range in speed is essential in ammonia-compressor practice, and is especially so here owing to the nature of the service. The governor has been designed to make the machine as flexible in speed as possible and to allow the attendant to make adjustments quickly and conveniently.

The governor proper, Fig. 4, is of the usual Rice-Sargent design, but has some most interesting additional features. It is driven by a layshaft from the main shaft through gear transmission designed after the transmission in an automobile. Six different speeds may be obtained by shifting these gears by means of the knob and recesses shown.

After the shift has been made, the gears may be locked by swinging over the arm *A*. A change of ten revolutions may be had for each shift in the gear box, and as six shifts are possible, this gives sixty revolutions. For variations of less than ten revolutions, the weight on the quadrant is used. This quadrant has thirty-seven notches, each notch giving a variation of one-third revolution. This, you see, gives $37 \times 3.333 = 12.3$ revolutions, which enables the operator to carry the speed beyond the ten possible by shifting gears. With this governor then, the speed may be varied by as low as one-third revolution between thirteen and seventy-five.

Synchronous Motor-Driven Tachometer

For accuracy in speed indication, Mr. Fairbanks, the chief engineer for the company, designed a tachometer driven by a synchronous motor; a small 25-cycle generator, belt-driven from the governor layshaft, supplies the current. This tachometer is very sensitive. Next to it on the gage-board is a combined indicating and recording steam-pressure gage, the pipe of which is on the compressor side of the throttle. As the pointer of the gage rises and falls as cutoff causes the pressure in the steam line to momentarily fluctuate, the movement of the tachometer pointer is seen to synchronize with it. The gage boards and the steam-control valves are shown in Fig. 5.

Formerly, the governor was lubricated by oil which dropped from the cup at the top of the casing. Sometimes the cup outlet or the tube leading from it would become obstructed. The oiler would not notice this condition for some time because the cup showed plenty of oil. To make a full or partly filled cup an indication of trouble proved good practice. The oil now goes through the cup on its way to the governor parts, but when the cup fills, it shows that the connections between it and the parts to be lubricated are obstructed.

Quick-Closing Throttle

Serious damage to compressors has occurred, because before the attendant could close the throttle it was too late to prevent accident. To avoid such conditions the 1000-ton machine has an electrically operated, quick-closing throttle. The quick-closing valve is at the left of the throttle, as shown in Fig. 6 and the bypass pedestal is at the immediate right, giving all steam control within an arm's length. The quick-closing mechanism consists of a solenoid-operated, spring-loaded pilot valve furnishing steam pressure to a balanced throttle. Provisions have been made to operate the solenoid by a push button on the watch engineer's desk.

Each valve on both steam cylinders may be operated separately by throwing out a clutch by simply turning a knurled knob provided for each valve, and pulling it open or shut with a bar. The steam valves are triple ported to give maximum

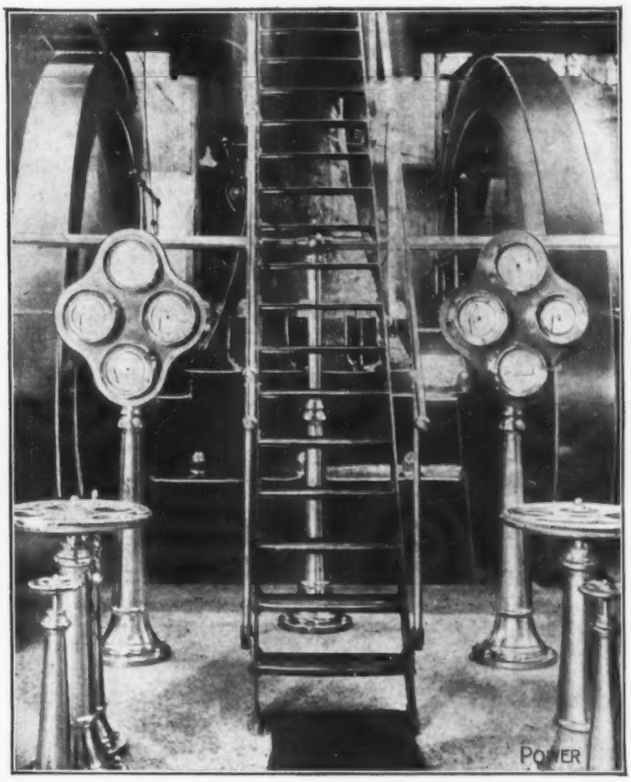


Fig. 5. Gage Boards and Control Valves for the 1000-Ton Machine

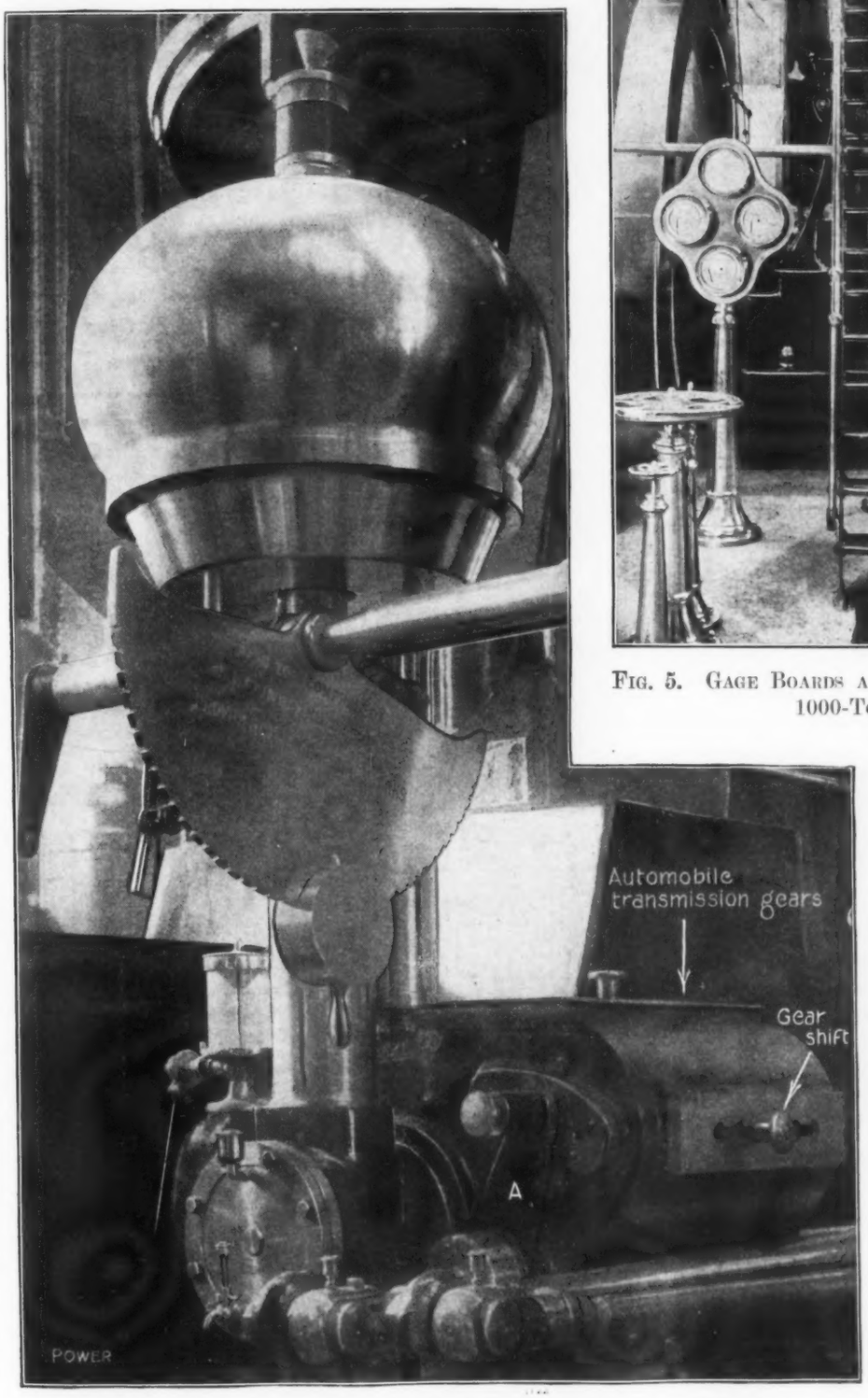


Fig. 4. Governor for the 1000-Ton Compressor; Driven through Automobile Speed Transmission Giving Unusually Wide Range in Speed

opening with minimum movement. The valve gear is shown in Fig. 7.

The jacket of the high-pressure steam cylinder gets superheated steam (150 lb., 125 deg. F. superheat, total 491 deg. F.) and this jacket water and steam together with all high-pressure drips go to a regenerator, the re-evaporated water passing into the low-pressure cylinder. The clearance volume in the steam cylinders of this ma-

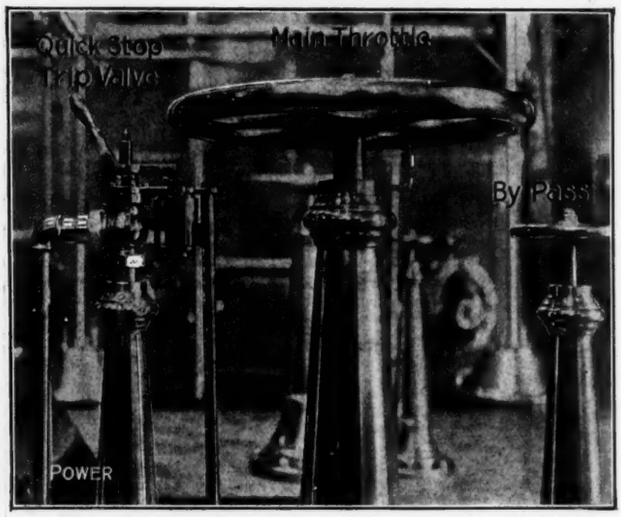


FIG. 6. RELATIVE LOCATION OF THROTTLE, BY-PASS AND QUICK-STOP TRIP VALVES

chine is quite low, being but 1½ per cent. Metallic packing is used in the steam end and all joints, such as those at the cylinder heads, valve bonnets, etc., are metal to metal, no gaskets whatever being used.

LUBRICATION OF THE 1000-TON MACHINE

Steam-cylinder lubrication is done with a noncompounded mineral oil without graphite. Instead of trying to obtain atomization of oil as it enters the cylinder, the object is to put the oil in cold and depend upon the piston to wipe it over the cylinder wall. Oil pumps are provided for hand lubrication for starting and for emergencies, the oil reaching the cylinder walls in five different places for each cylinder. Fig. 8 shows one of these cups mounted on the head of the low-pressure cylinder. The cup for the centrifugal oiler for one of the crankpins is shown in Fig. 9. The centrifugal oilers (provided on all compressors and brine pumps) have a lip on the inside of the receiving shell to keep the oil from spilling out by gravity, as it will with most types of "banjo" oilers when the centrifugal force is reduced below a given amount. One of the large oil cups as used on the fill-pieces between the ammonia cylinders and A-frames is shown in Fig. 10; these oilers supply the wristpins and guides. Emergency lubricators as used on the steam end of the 800-ton machine are shown in Fig. 11. Pipes run to the top and bottom of the cylinder and the indicator connections are used to get oil to the side; Fig. 12 shows how the low-pressure valve rods are lubricated. The present forced-feed lubrication system will be displaced by a gravity-type system.

The three ammonia cylinders are each 30x50 in., the volume of each, neglecting piston clearance, which is only 10-thousandths of an inch, being 3534 cu.in. and the displacement of the machine at 75 r.p.m. (neglecting clearance) is 920 cu.ft. per min. Each ammonia head contains fourteen valves, and an extra head is kept on a hand truck near the machine to be lifted by the crane and put on in a hurry when emergency demands; this head is shown in Fig. 12a.

TWO SUCTION PRESSURES HANDLED

The back pressures for the warehouse and street systems are different, but are handled by the same compressor. This is accomplished by taking the low-pressure gas through the suction valves for 48 in. of the stroke and then admitting the high-pressure gas from the second system through ports uncovered by the piston, the high-pressure compressing the low-pressure to a volume in direct ratio to the pressures and at a lower temperature than would be normal with the high-pressure gas alone, thus greatly increasing the capacity of the compressor.

All metal surfaces of the ammonia end of the compressor with which jacket water is in contact are painted heavily with boat bronze, a paint made of spar varnish and bronze powder, to resist the corrosive action of the harbor water, which contains free chlorine from the sewage. Also it contains magnesium chloride, and experience shows that when salt water is heated the magnesium chloride in solution tends to dissociate into magnesium oxide and hydrochloric acid on the application of heat, the hydrochloric acid, of course, being highly corrosive. This boat bronze proves to be a good corrosion-resisting material for such service. Like other paints for the same or similar purposes, it must be well brushed into corners and recesses and for this reason it pays the one in charge to closely inspect the work. The corners of nuts especially should be well coated, otherwise they will waste away and be crushed and sheared off when a

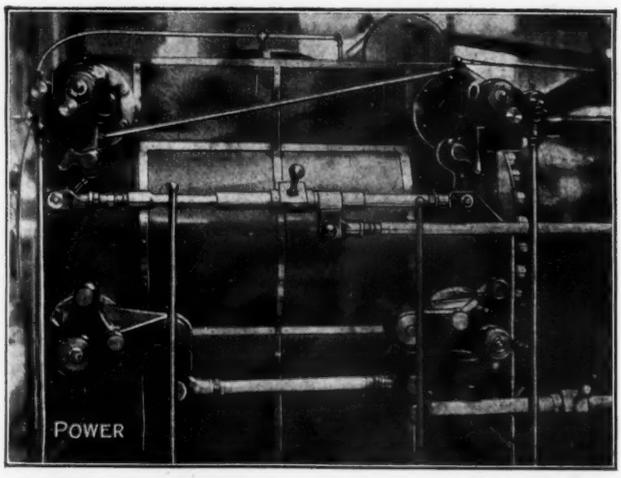
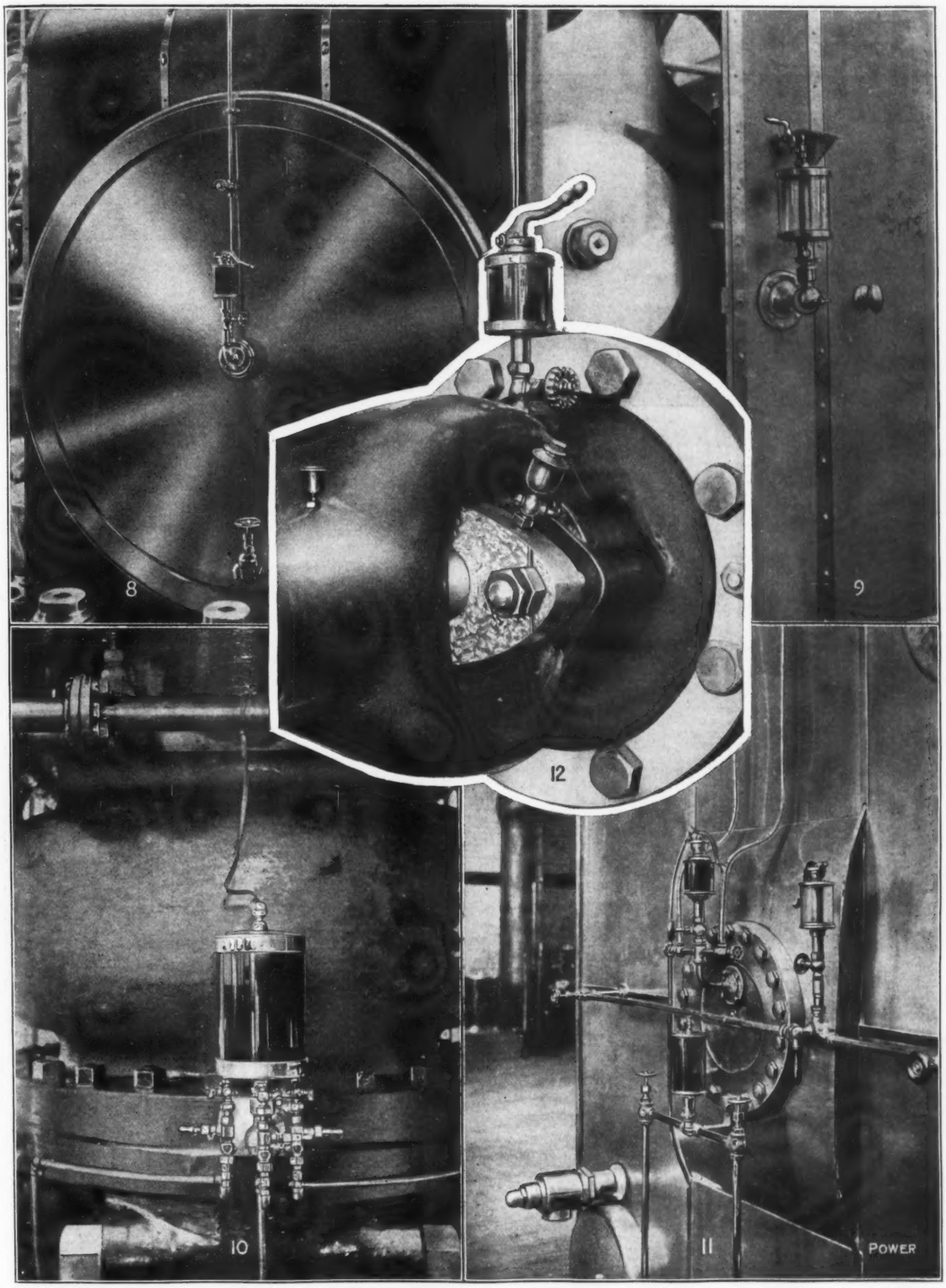


FIG. 7. VALVE GEAR OF THE LOW-PRESSURE CYLINDER

wrench is applied, as is often necessary when stopping ammonia leaks when tightening a plug in the ammonia head.

The water for each cylinder enters the jacket through a 2-in. pipe, having four openings below the end and an umbrella-shaped hood over the top to deflect the water downward, as shown in Fig. 13. This gives a better cooling effect than if the water were allowed to discharge from the end of the pipe direct, because it stratifies the water.



LUBRICATION FOR THE 1000-TON AMMONIA COMPRESSOR

Fig. 8. Oil pump on head of low-pressure cylinder. **Fig. 9.** Oil cup for one of the large crankpins. **Fig. 10.** Oiler for the vertical guides and the wristpins. **Fig. 11.** Oil pumps on indicator pipes of the 400-ton machine. **Fig. 12.** How the valve stems for the big compressor are lubricated.

The high speed (75 r.p.m.) for which the compressor is intended calls for a valve of a design that will allow it to open and close rapidly, be tight and not wear

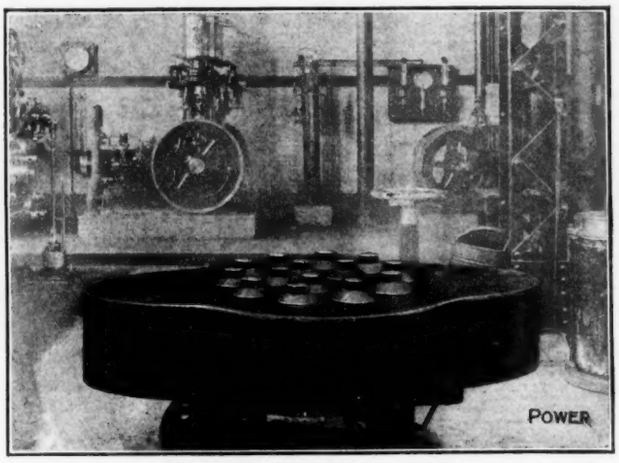


FIG. 12A. ONE OF THE AMMONIA HEADS OF THE 1000-TON MACHINE

quickly. Fig. 14 shows one of the suction valves, and Fig. 15 one of the discharge valves. These illustrations are almost exact reproductions of the assembly drawings sent to the builders and show and state the details so clearly that no further description is necessary.

It should be understood that "1000 tons," as applied to the compressor, is really only a name, for at 75 r.p.m., the normal speed, the machine develops 1250 tons.

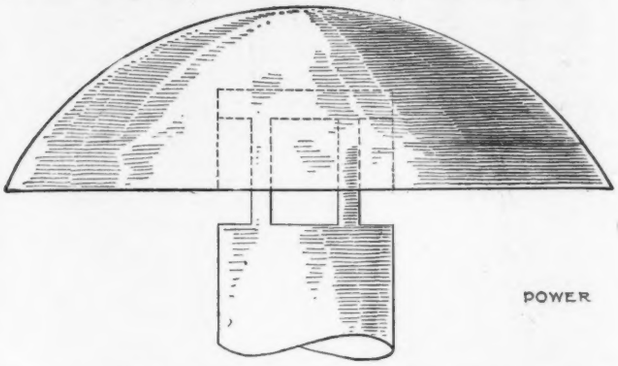


FIG. 13. ONE OF THE UMBRELLA DEFLECTORS FOR THE COMPRESSOR JACKET WATER

The machine has been admired by many visiting designers and builders and all commend it most highly, but many remark that to build such machines is commercially prohibitive because of its cost. The machine complete cost $75,000, and as its rated capacity at 75

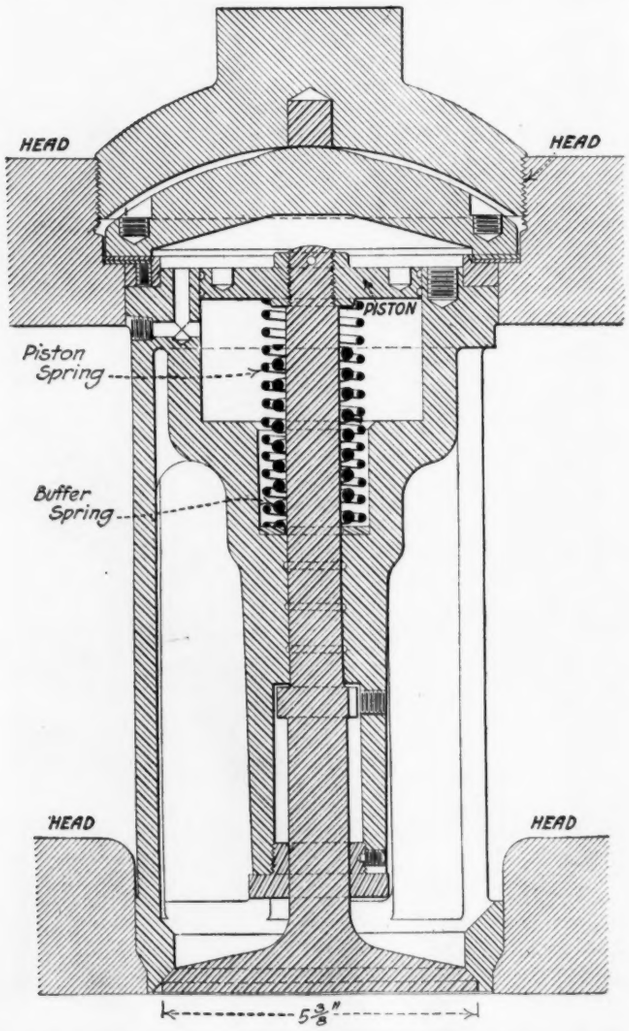


FIG. 14. SUCTION VALVE OF THE 1000-TON COMPRESSOR

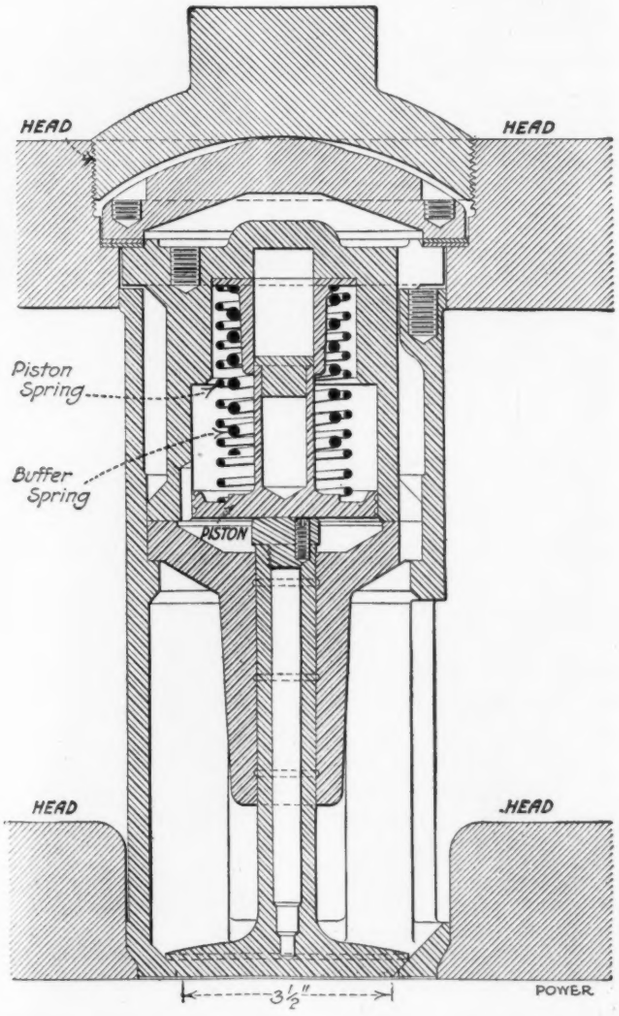


FIG. 15. DISCHARGE VALVE FOR THE 1000-TON COMPRESSOR

r.p.m. is 1250 tons, the price per ton capacity is $60. The contractor was in no way responsible for the machine. If, when the various parts arrived, the measurements were as specified though in error enough to make trouble in assembling on the foundation, the responsibility was entirely up to the designer. The same was true for the performance of the machine.

Figs. 15a and 15b show diagrams from the ammonia end of the 1000-ton compressor. The reader will recollect that this machine receives gas at one pressure

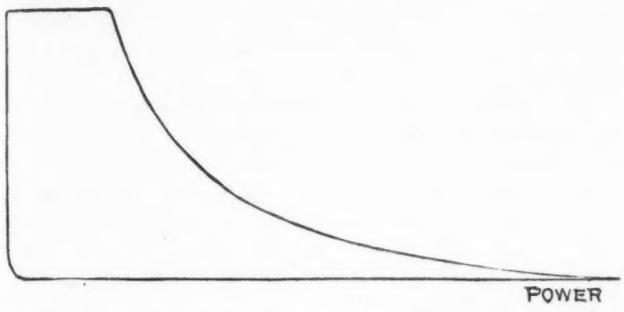


FIG. 15A. AMMONIA DIAGRAM, ONE SUCTION PRESSURE

Discharge pressure, 123 lb.; suction pressure, atmospheric; scale of spring, 80 lb.; 30 r.p.m.; cylinder, 30x50 in.

from the warehouse system, and at another from the street system. The first figure shows a diagram taken while gas at only one pressure was being handled. The suction lines follow the atmospheric lines in both diagrams. Notice that there is no perceptible reëxpansion, the valve action being exceptionally good during all events of the cycle. Fig. 15b was taken while the machine was receiving gases at two different pressures, the high-pressure

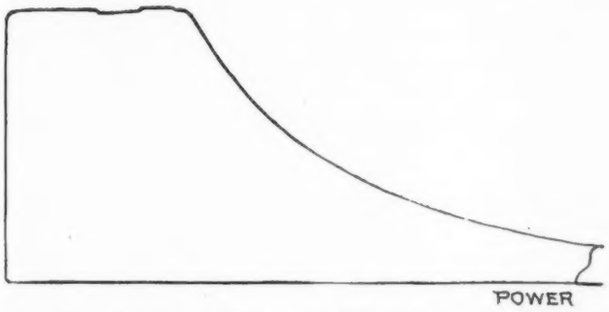


FIG. 15B. AMMONIA DIAGRAM, TWO SUCTION PRESSURES

Discharge pressure, 123 lb.; low suction pressure, atmospheric; high suction pressure, 17 lb.; scale of spring, 80 lb.; 30 r.p.m.; cylinder, 30x50 in.

gas entering through a port in the piston after it had traveled 48 in. of the 50-in. stroke. Referring to the suction end, it will be seen that the port area in the piston is sufficient to allow the high-pressure gas to get in before the end of the stroke is reached. The diagram also shows that the piston port is covered before compression can force the gas back into the port. The advantage of using two suction pressures is, of course, to increase the capacity of the machine. How much it increases it is apparent from the diagrams, for the first diagram, where one pressure is used, has considerably more area than the second where two gases are admitted.

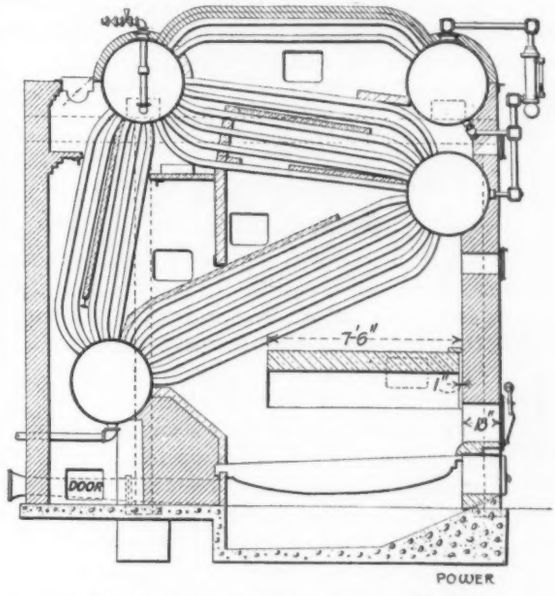
To Find the Area of an Ellipse—The area of an ellipse is equal to 0.7854 times the product of the axes of the ellipse. Example: The major axis is 15 in. and the minor axis 10 in. Applying the rule,

$$15 \times 10 \times 0.7854 = 117.81 \text{ sq.in. Ans.}$$

Improved Badenhausen Water-Tube Boiler

The original Badenhausen water-tube boiler, described in the Sept. 22, 1908, issue, consisted of four drums, the lower or mud drum being connected by tubes to the rear and lower front drum. The upper front drum was connected to the top rear and bottom front drum by banks of tubes.

The present design of this boiler retains the four drums in practically the same relative positions, but the arrangement of tubes between them is different. The lower front water drum and the rear steam and water drum are connected by tubes to form the course of circulation for the water. The upper front steam drum is connected through the water column opening to the lower front drum.



SECTIONAL VIEW OF BADENHAUSEN WATER-TUBE BOILER

The boiler is supported by heavy steel I-beam framing. The water drum is suspended from heavy bolts secured to these I-beams, and the mud drum is suspended from the tubes which connect to the rear steam and front water drums. This arrangement gives flexibility to the boiler, as but one drum is stationary, and although variations of temperature occur in the boiler, the liability of the tubes being distorted or torn out from the drums is remote. The front steam drum is placed upon a heavy steel support and connected by steam tubes to the rear drum and by water connections to the front water drum.

All drums are designed and built according to the Massachusetts and Ohio boiler laws, with double butt-strapped and double-riveted joints.

The drum heads are made of extra-heavy steel with manholes pressed in. The tubes enter the drums radially and are expanded and flared. The absence of short tubes with the middle lower than their outer ends does away with all pockets for dirt or scale.

The arrangement of the tiling and baffling is shown in the illustration, a hand-fired furnace. No special baffles are needed and standard tile only is used. An examination of the baffling will indicate how the hot gases must pass all of the tube-heating surface.

The boiler is cleaned internally by removing four manhole covers and inserting a tube cleaner into the tubes. The outside of the tubes is cleaned by inserting steam lances from the boiler front. The necessary repairs are facilitated by the tubes being spaced alternately wide and narrow, permitting the replacing of any tube without disturbing any other tube; no baffles need be disturbed. Owing to the cycle of circulation in the boiler, impurities are finally thrown into the large mud drum, when they may then be blown off. As the feed water enters the top rear drum and passes down the rear outer tubes, the scale will be found in these tubes and also in the mud drum.

The main characteristics of this boiler are that the area of the tube entering the drums and leaving them is practically the same, thus permitting unrestricted circulation; the large disengaging surface of the boiler, which is the total area of the tubes discharging into the rear drum; and the fact that the steam in passing through the steam tubes is dried and slightly superheated.

This boiler is manufactured by the Badenhausen Co., 1429 Chestnut St., Philadelphia, Penn.

Thick Boiler Plates

By S. F. Jeter

The proper thickness of fire plates for horizontal tubular boilers is a mooted question. In practice five-eighths of an inch seems to be about the maximum, owing to the trouble at the girth seams with plates of even this thickness.

There is no conclusive evidence that plates of five-eighths of an inch and over are more likely to give trouble in the *solid part* under the same operating conditions than thinner plates, and they have been used with apparent success so far as the solid part of the plate is concerned. Since there is a tendency in proposed boiler rules and laws to limit the maximum *tensile strength* for the shell plates, the question arises as to what the limit in thickness may be. The first trouble with thick sheets appears at the girth seams where the plate is doubled.

There is need of experimental data to show how the transmission of heat occurs at this point. The belief at present is that the principal resistance met with is at the two surfaces, therefore there can be but little heat transmitted through the outer lap of the joint except where the two plates are held in intimate contact by the rivet.

It is a fact that well fitted seams show less tendency to fire-crack and to give other trouble than those not so well fitted, but this does not prove the case conclusively. For example, Fig. 1 represents a section of a poorly fitted seam before the edge of the outer plate was calked. While poor fitting would tend to prevent the proper transmission of heat through such a joint, the plate along the calking edge would also be under a severe strain when the rivets pull the two courses together. Both conditions would tend to cause fire-cracks where local heating occurred.

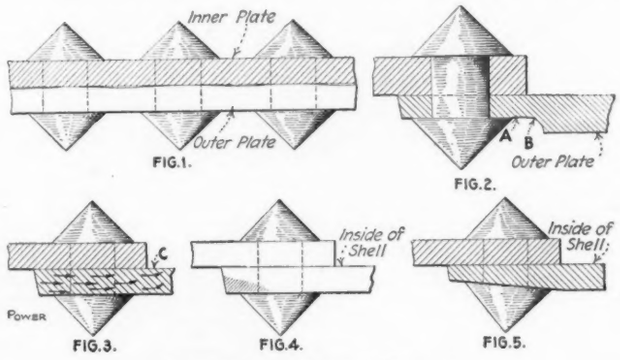
The stress on the edge of the sheet by the use of a drift pin to bring holes in line would be almost certain to produce fire-cracks.

Punching rivet holes, drifting, bevel-shearing and the probability of the imperfect fitting of the courses all have considerably greater effect on thick than thin plates. These are some of the reasons why trouble at the girth seams may be experienced, which is not alone caused by poor heat transmission on account of the thickness of the plates. Attempts have been made to avoid the foregoing trouble by reducing the thickness of the outer lapping plate at the seam, Fig. 2. I question the advisability of the method shown in the illustration because it produces a local weakness at a point where considerable strain due to expansion and contraction occurs, and it may be found that the plate has a tendency to crack at some point between *A* and *B*.

There is reason for believing that the heat is largely transmitted lengthwise of the shell, indicated by the arrows in Fig. 3. This is the reason for restricting the length of lap of such joints.

When the Massachusetts Rules first went into effect, it was specified that all riveted joints should have the distance from the center of the rivet hole to the edge of the plate not less than one and one-half times the diameter of the rivet hole, but this rule had to be changed and it now applies only to longitudinal seams, because that amount of lap on a fire seam was not satisfactory as was proved by experience.

In case of trouble at a girth seam the boiler maker chips the edge of the plate, primarily to secure a new edge



Joints for Thick Plates

of metal to calk, but it also improves the conditions by shortening the lap and placing the new calking edge closer to point *C*, Fig. 3, and therefore it is not so apt to become overheated. Frequently, the result is that seams that could not be kept tight as first constructed remain tight after this treatment. A microscopic examination of the edge of the plate of a girth seam exposed to the fire was made by an engineer connected with a prominent boiler company. The indications were that the part of the outer lapping plate shown shaded (Fig. 4), was exposed for a long time to temperatures high enough to cause structural changes. In short, it was burned, while the metal elsewhere was in good condition. This would indicate that the transmission of the heat was lengthwise of the shell, as previously stated.

From the foregoing, I believe that thick plates could be used by constructing the joint in the following manner: First, by using rivets with large heads, because all of the surface covered by the rivet heads is protected from the heat, which is conducted through the body of the rivet to the water inside of the boiler. Second, by having the courses well fitted together so as to get the maximum benefit from the contact between the plates. Third, by having the calking edges of the plates planed instead of bevel-sheared. Fourth, by reducing the thickness of the edge of the overlapping plate (Fig. 5), so that the max-

imum lengthwise heat transmission may be obtained. This gradual reduction does not weaken the plate locally, as in Fig. 2, but it certainly improves the longitudinal transmission of the heat.

There may be some objection to driving the outer rivet head on a slanting surface, but since the original head of the rivet would be in contact there should be no trouble experienced if a die of the proper form is used and the rivet is held in the right position in the ram of the riveter.

Headroom for Smokeless Settings*

By Osborn Monnett†

The accompanying table is intended as a summary to compactly give the minimum headroom requirements for good performance for the combinations of boilers and furnaces found in use in Chicago. The "headrooms" were taken from actual installations, which are running satisfactorily. So far as capacity is concerned, there is no reason why any of the combinations listed could not run with a clean stack, considerably above rating, provided the draft was sufficient and proper methods of operation were used. While not intended for high ratings or for special conditions, the settings may be taken as standard for ordinary commercial work in the average industrial plant.

Horizontal Return-Tubular Boilers

For boilers of this type, department furnaces Nos. 6, 7 and 8 are quoted from shell to dead plate. This dimension was given to insure a satisfactory bridge-wall and to obtain proper area. When the ashpit is low it is assumed that the floor of the combustion chamber will be lowered sufficiently to get the proper areas through the furnace, as set forth in previous articles on such settings.

For underfeed stokers the dimension from shell to dead plate on horizontal return-tubular boilers is given, leaving the depth of ashpit to the individual characteristics of the stoker used. Of course, with underfeeds the combustion chamber need not be lowered as in the case of hand-fired furnaces.

With the exceptions noted, all quotations on horizontal return-tubular boilers are from shell to floor line, as the equipment consists of proprietary furnaces, in which the manufacturer can suit his own ideas as to the location of the grate.

The heights given for side-feed furnaces are for standard ratios between grate and heating surface. For freak settings using wide boilers or for ratios of grate to heating surface higher than standard, the headroom must be increased to correspond with the greater spring of the arch necessitated by the wider span. With this style of stoker the clinker bar should be located at or slightly above the floor line.

Taylor and Westinghouse underfeeds are not quoted on horizontal return-tubular boilers as they are not generally installed under units of small capacity. A 72-in. by 18-ft. boiler would probably be the smallest unit which these stokers might serve. In this case a headroom of 84 in. would be recommended.

Water-Tube Boilers

With water-tube boilers no distinction has been made between boilers having 1-in. pitch to the foot and those having 1½-in. pitch, as it has been found that the difference in practice so far as furnace design is concerned is negligible. Boilers with 3¼-in. pitch affect the furnace design sufficiently to warrant a separate column. Higher headroom is required principally to give the proper cross-sectional area in the combustion chamber so that the heat will not be "bottled" in the furnace, and to insure long flame travel by raising the heating surface far enough away from the grate, especially at the inner end near the bridge-wall.

HEADROOM REQUIREMENTS FOR SMOKELESS SETTINGS
(All Dimensions in Inches)

	Furnaces	Horizontal Return Tubular: 54 Shell	60 to dead	66 dead	72 plate	Water Tube: Hor. Baff. 1-1¼" Pitch	Vert. Baff. 1-1¼" Pitch	Hor. Baff. 3¼" Pitch	Vert. Baff. 3¼" Pitch	Continental or Scotch Marine
						Front header to floor				
Hand Fired	No. 6	32	34	34	36	72	*	78	*	**
	No. 7	36	40	40	42	†	†	†	†	**
	No. 8	32	34	34	36	72	*	78	*	**
		Shell to floor								
	Down draft	60	60	60	60	72	*	78	*	*
	McMillan	52	54	60	60	72	*	78	*	**
	Twin fire	58	60	62	64	72	*	78	*	*
	Semi. ext. refuse burning	††	††	††	††	84	*	90	*	*
Gravity Feed	Burke	48	48	50	54	60	*	66	*	Full extension
	McMillan	48	48	50	54	60	*	66	*	Full extension
	Chain grate	72	72	78	78	84	114	96	120	**
Front Feed	Moore	48	54	60	60	72	102	78	108	**
	Roney	60	60	60	72	84	108	90	120	**
	20th Cent	54	60	66	72	84	108	90	120	**
Side Feed‡	Detroit	66	72	78	84	90	*	96	*	Full extension
	Model	66	72	78	84	90	*	96	*	Full extension
	McKenzie	66	70	70	70	90	*	96	*	Full extension
	Murphy	66	72	78	84	90	*	96	*	Full extension
		Shell to Dead Plate								
Under Feed	American	42	42	42	42	78	96	84	102	**
	Jones	36	38	40	42	78	96	84	102	Min. diam. of furnace 36 in.
	Taylor	**	**	**	**	84	102	90	108	**
	Westinghouse	**	**	**	**	84	102	90	108	**

* Combinations not recommended as smokeless settings.
** Combinations not ordinarily met with in practice.
†Not adapted to water-tube boilers.
†† Applied only to water-tube boilers: No. 8 better for H.R.T. boilers.
‡ Exceptionally wide settings will need more head room to take care of extra spring of arch.

Unsatisfactory Combinations

There have been some combinations of vertically baffled water-tube boilers and furnaces which have not resulted in smokeless settings. The dampening action of the tubes combined with the short flame travel results in the production of too much smoke for congested communities. These combinations are noted in the table.

Vertical Boilers

It has been found practically impossible to formulate a set of standard conditions for vertical boilers. In general, all furnaces in connection with these boilers should be set full extension, giving the maximum flame travel which the floor space will permit in any given situation. The exact amount of extension depends upon so many variable conditions that each case must have individual study before quotations can be made. With mechanical stokers serving vertical boilers it is not difficult to get a smokeless setting, but with hand-fired furnaces the exten-

*Copyright, 1914, by Osborn Monnett.
†Smoke Inspector, City of Chicago.

sion required to get proper mixing action frequently results in a cumbersome combination.

Continental Boilers

With this type of boiler the solution is a full extension, gravity-feed furnace, or an underfeed stoker installed directly inside the corrugated flue. The application of furnaces to this type of boiler is limited to a few types as noted in the table.

Superheat for Corliss Engines

By E. R. Pearce

The steam consumption of all types of engines will be improved by a moderate degree of superheat. The chief point, however, is the design of the cylinder, for in some, appreciable distortion takes place with ordinary steam temperature only, so that trouble may be caused by the addition of even 80 to 100 deg. of superheat.

In the average Corliss engine, with tight valves and pistons and the cylinder not steam jacketed, little is to be gained in having more than 80 deg. of superheat at the inlet valves. That is, the superheat should be just high enough to insure dry steam at the cutoff.

Superheat, besides reducing the steam consumption, will allow of considerably less cylinder oil being used, providing, of course, that an oil having suitable properties be used. This reduction in oil is probably due to the removal of moisture in the steam, thereby preventing the oil from being washed off.

In ordinary compound and triple-expansion engines no effects of the superheat will be found past the high-pressure cylinder, even in short-stroke, high-speed types, unless they have a late cutoff in the high-pressure cylinder, use high superheat (150 to 175 deg.), and are fully loaded; in which case a slight amount of superheat will be found in the high-pressure element. Before applying superheat to a Corliss engine which has been running for a few years on saturated steam, it is advisable to remove all the valves and take off the sharp edges from the ports as well as the valves. This will prevent the scraping off of the oil, which naturally will be a little thinner at the higher temperature. Scraping off of the oil is the cause of grooving in many Corliss engine valves.

It is not advisable to employ more than 50 deg. superheat with slide-valve engines running under more than 100 lb. pressure, unless the oil be so fed into the cylinder as to enter between the valve and the face; even then 50 deg. is high enough.

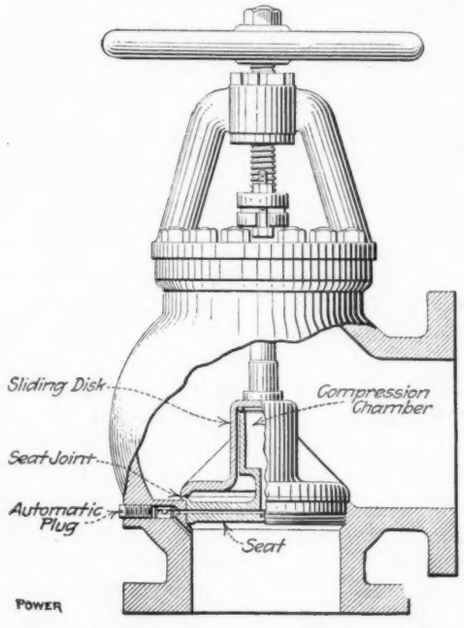
In modern Corliss engines, where the high-pressure cylinder is properly steam-jacketed and the steam passes around the jacket before entering the cylinder, it is best to carry about 120 deg. superheat for a steam pressure of 160 lb. gage. In many engines of this type, with a good load, the high-pressure exhaust is practically dry but not superheated, so that when the steam in the jacket is giving a reading of 120 deg. of superheat, at the point of cutoff it will be in the neighborhood of 90 to 100 deg.

In a plant having cast-iron steam pipes and fittings with a pressure over 100 lb. gage, it is not well to use more than 60 to 80 deg. superheat. In fact it will be far safer to scrap the cast-iron pipes and put in steel, otherwise cracks may develop at the roots of the flanges, especially if the plant is shut down every night.

Before changing a plant from saturated to superheated steam, there are factors which require careful attention, otherwise it may be found that the financial outlay is more than the saving that can be attained.

Bradford Automatic Nonreturn Boiler Stop Valve

The principal feature of the Bradford automatic nonreturn boiler stop valve is the construction of the automatic disk, seat and plug. The cushion, or compression chamber, in the automatic seat has a small area (see illustration) and is controlled by an automatic plug, adjustable for different pressures. This construction allows ample clearance to the automatic disk and prevents it from seizing the piston over which it slides without the use of a packing ring. At the same time the automatic disk is controlled by the automatic plug.



Bradford Automatic Nonreturn Stop Valve

Under normal working conditions the steam flow is away from the boiler and its stop valve. When an accident to the boiler occurs the flow is reversed through the valve toward the rupture, causing the valve disk to receive the greatest pressure on its top and it automatically closes to its seat.

Another feature of the valve is its ability to cut in a dead boiler to the line automatically. The valve requires the dead boiler to attain a pressure a few ounces per square inch greater than the pressure in the live boilers, and then cuts it in and equalizes the pressure without attention by an attendant.

This valve is manufactured by the Bradford Manufacturing Co., 384 Atlantic Ave., Boston, Mass.

Correct Use of the Word "Fitting"—The National Tube Co., in its "Book of Standards," defines the word fitting as "A term used to denote all those pieces that may be attached to piping in order to connect them or provide outlets, etc., except that couplings and valves are not so designated." Plugs and caps used to close an end of a pipe are also included under the term fitting.

Editorials

Manufacturers' Tests

Some manufacturers are sadly deficient in the making of tests and publishing the results of those tests. They seem to be willing to "take a chance" with their products and claim them to be better than competing makes without first making exhaustive experiments to prove their statements.

For example, the maker of a certain appliance advertised it extensively, and it is a very good piece of machinery, but when pressed closely by a prospective buyer, he had to admit that many of his claims were based on his judgment as to the relative values of his and competing appliances made for the same purpose.

The prospective buyer, however, wanted proof, and so before buying anything, obtained consent of the most prominent competing manufacturers to test out their machines in his own way. All of the manufacturers seemed pleased with the idea, so they must have believed in their respective products. Some of them offered to pay the expenses of the "tester," but the prospect preferred to do the whole thing "on his own hook" and thus be under obligations to nobody.

After the tests the manufacturer whose appliance tested best was given the order. Now he is making use of the results of the tests in his advertising. He has something tangible upon which to base his claims and as a result his business is increasing.

It does not seem altogether fair that tests should be "up to the purchaser," as is so often the case. The manufacturer should know what his product can do. He should make comparative tests of his own under the supervision of unbiased authorities, so that there can be no question as to authenticity of results.

Many appliances are sold daily on their "merit," and yet when it comes down to facts the manufacturers themselves cannot give absolute proof of the merit about which they so glibly write and speak. Such a situation is indefensible.

Recognition for the Engineer

The operating engineer's work is not spectacular, but occasionally it gets a measure of recognition which encourages the man behind the throttle to use his head and study his employer's problems with some hope that initiative will be appreciated. An unusual instance in which many hours of hard work resulted in deserved advancement has been receiving front-page publicity in the Boston press, to the credit of the modest engineer of the Deer Island steam plant of the Penal Institutions Department, Lawrence Hackett. It seems that for some years past the public authorities at Boston have been considering the desirability of shutting down the five existing boiler plants on the island and building a central heating and power station. The project got so far as to lead to the employment of an outside engineering expert to investigate and report upon the situation, who recommended dismantling the plants now in service and installing an entirely new centralized outfit at an estimated cost of about one hundred and eighty-one thousand dollars.

At times it is better to make the best possible use of means at hand, adding a moderate outlay for new equipment judiciously placed, than to scrap a plant, tear up every existing unit and level present structures. The engineer "on the job" saw this to be the case at Deer Island. He quietly set to work on his own account, obtained private bids on the cost of three new eighty-four-in. boilers installed in one of the existing boiler houses, estimated the saving in fuel and labor by normally supplying all but one remote building of the institution from the new units, holding three good sixty-inch boilers in reserve in another boiler room, with ample tie-line connections between the old and new batteries, and schemed out the elimination of two old boiler plants, with a total reduction in labor of seven firemen and total yearly estimated savings of fifteen thousand dollars. The estimated cost of fixing up the plants according to the new scheme was about five thousand dollars.

A report was then voluntarily submitted to his superiors, favorably passed upon as to its general plan by the consulting engineer of the Boston Finance Commission, Guy C. Emerson, and transmitted to the mayor of Boston. The chief executive of the city was so much pleased with the initiative shown by the author of the report that he promoted him to the position of chief engineer, with a salary increase of fifty dollars per month, and the City Hall reporters "saw a story" in the affair and gave it enthusiastic if technically misguided publicity.

The subject of all this front-page copy was oblivious of its newspaper interest until shown a copy of Boston's most conservative daily by a representative of POWER, and, in common with others of his kind, kept right on with his daily duties while others did the talking. The daily press "played up" the engineer's part with too little regard for the concurring professional opinion of the Finance Commission, but this fact in no wise detracts from the credit which the chief executive of the city placed upon the shoulders of the new chief operating engineer, who made no attempt to criticise the views of others but simply presented to his superiors a plain and unvarnished tale of how the city could save an investment of certainly one hundred and seventy-five thousand dollars by effecting various changes in the plant situation as above roughly outlined.

There is an encouraging lesson from all this for the engineer who feels sometimes that the isolated character of his work cuts him off from a fair chance of advancement, and who can see nothing ahead of him but years of routine grind. It is true that advancement does not come even to all who may perhaps be qualified to fill larger and more responsible positions; human affairs

are not yet conducted with one hundred per cent. efficiency, and probably they never will be. But never was it more certain that the man who can see an opportunity to make himself more useful and who acts with that aim constantly in view is the one most likely to succeed in the engineering profession, and for the very good reason that in this line of work bluff won't go. It is founded upon great natural laws which are as permanent as anything known to the mind of man, and the engineer must work in harmony with those laws and connect himself in parallel with the stream of progress if he is going to operate in economic synchronism with his fellow seekers after the truth. That is precisely what has been going on at Deer Island, and it is going on everywhere else that engineers are striving to "go the limit" in their services to their employers without measuring their devotion to duty in a chemical balance! Giving good measure, pressed down and running over, is what counts most, and if it is slow in bringing external reward, it none the less follows that the sense of making good goes far to encourage the ambitious worker to keep up his efforts.

An Ignored Cause of Smoke

Large sums are annually expended in efforts to overcome the smoke nuisance, and many ingenious devices and systems of arches, steam jets, etc., have been devised, some of which have been fairly successful. But all entail more or less first cost and operating expense, and the best of them fail in many instances where smoking occurs only occasionally from some supposedly inexplicable cause.

This "inexplicable cause" is simply foul boiler tubes. Though dirty tubes have long been recognized as seriously hindering the transfer of heat, nevertheless, consideration has not been given the question as a direct cause of smoke. Excess or insufficient air, the cooling of the volatile constituents before thorough ignition of the soot-laden gases takes place, failure to raise the temperature of such gases to that required for combustion—all have been charged as the cause of smoke. Unquestionably these are causes, but they are not the only ones.

When fuel is burned under a clean boiler, the products of combustion and the volatile gases, whether they have been completely consumed or not, pass from the combustion chamber to the boiler tubes, where the transfer of heat takes place. The cleaner the boiler tubes, the more rapid and complete the transfer of heat will be. If soot is carried in suspension, it is deposited on the cleaner sections of boiler tubes, because of the temperature difference. As the soot accumulates, the heat-absorbing capacity of the boiler is gradually reduced, and the hot gases are not so deflected from their natural path and their passage to the smoke flue is not diverted to the tubes to such an extent, because the temperature difference is not so great as formerly and more of the soot is carried past the tubes to the chimney. Precipitation of soot on the tubes thus becomes gradually less rapid, but so also does the transfer of heat to the boiler contents. The result is that the visible smoke increases at about the same rate as the efficiency of the boiler decreases.

Cleaning the tubes restores the heat transfer and at the same time reduces the proportion of soot which would otherwise be carried to the chimney and in many localities lead to trouble with the municipal authorities.

It is true that cleaning the tubes will not reduce the loss due to failure to consume the soot, but avoiding trouble with the authorities is commendable, and it is gratifying to any management to be able to avoid a cloud of black smoke.

The clean boiler is of greater importance, however, and a smoking chimney due to unclean heating surfaces is a signal to turn on the steam hose or to start the soot blowers.

Superheat

The observations of E. R. Pearce on the use of superheated steam in Corliss engines (page 886), although founded on English practice, may be taken as fairly representative.

Not many years ago, when the advent of the steam turbine brought superheated steam to the fore, its advocates and opponents waged many controversies in which extravagant claims were made on the one side and dire predictions on the other. Subsequent experience has justified neither of these extremes.

Superheat has stood the test, but the theoretical economies of very high temperature have given way to commercial considerations—that is, above a certain point, the gain due to high superheat has often been offset by the additional cost of fittings. Consequently general practice now seems to favor moderate superheat; from 100 to 125 deg. for turbines and 50 to 80 deg. for reciprocating engines. There are exceptions, of course, notably in special cases, such as the locomobile, poppet-valve engines and the Ferranti turbine.

While superheat is now the rule rather than the exception in steam-turbine plants, its use in reciprocating engines is still far from general in this country. Although undoubtedly more effective in the long-stroke, slow-speed type than in the short-stroke, high-speed type, there are many instances of the latter where it might be adopted to advantage. However, here again local conditions, commercial considerations, and sometimes prejudice, are deciding factors.

Many comparative tests have been made on engines running with and without superheat, which have invariably shown a lower steam consumption with the former. But this does not tell the whole story, for it does not show the cost of producing the superheat. This is comparatively easy to figure and the net saving is usually taken as about one-half the decrease in steam consumption. The absence of sufficient test data to verify this, however, has probably made many plant owners hesitate in deciding on superheat; for, after all, the average plant owner is "from Missouri."

We were accused the other day of printing something that was "not fair, nor correct, nor honest." Our reply was that we never printed anything unless it was all three of those, if we knew it, and that if we should find we had unwittingly done so, we would make all amends possible immediately. To put all the emphasis we can on this statement we are hereby making it a public declaration of principle. We have been working on this policy ever since the first issue of POWER appeared, and we wish to assure our readers that we are as jealous of our reputation for rectitude as ever. When we find we have made mistakes we acknowledge them.

Correspondence

Cranks and Criminals

The perpetual-motion crank proposes to produce energy where none existed before—making something out of nothing. Likewise the schemes that are periodically proposed to convert ashes into fuel by the addition of a magic chemical compound. An analysis of some of these compounds would probably disclose as one of the ingredients, the left hind foot of a rabbit or some equally potent "charm." These schemes are always proposed by ignorant or unscrupulous men.

So much has been said about so called accidental inventions that many people put in a great deal of their time tinkering with mechanical contrivances hoping to make a lucky strike. In most of these cases a knowledge of the rudiments of mechanics would save the afflicted much time and money.

C. O. Sandstrom.

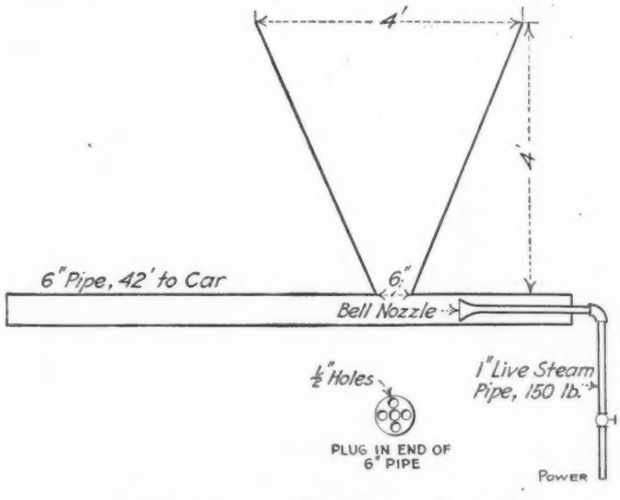
Kansas City, Mo.

Live-Steam Ash Ejector

We tried out the scheme shown, and could not get it to work. Will some one who is successfully blowing cinders with high-pressure steam tell us what the trouble is?

We have a bucket elevator to carry cinders from the basement of the boiler room to a screw conveyor, delivering the cinders to the rear of the building, and as we could not have a track at this point, we have to drop the cinders on a platform and wheel them to the car.

We cut a hole in a 6-in. pipe and built a hopper 4 ft.



Ash Ejector Failed to Work

high and 4 ft. wide above and secured it to the pipe, terminating at the bottom with a 6x6-in. opening.

Entering the end of the 6-in. pipe is a 1-in. steam line with a bell nozzle, the end of which is 18 in. from the hopper opening. The 6-in. pipe is 42 ft. long and is nearly level. The elevator was started and the live steam turned on, but the cinders would not blow through as the condensation of steam would wet the fine ash, completely plugging the 6-in. line, and the steam blew out at the hopper. Our steam pressure is 150 lb.

We have also tried several other arrangements—closed the air opening in the flange through which the steam pipe enters the 6-in. pipe, advanced the nozzle gradually up to and even beyond the hopper opening, and finally used a 6x6x4-in. tee at the junction of the ejector pipe, and a hopper with a 12-in. piece of 4-in. pipe between the tee and the 1-in. steam pipe. This was all to no purpose; the ejector will not eject.

Have any readers used steam successfully for blowing ash in this way?

E. H. Clark.

Harrisburg, Ill.

Engine Salesman's Experience

The Corliss engine builders for whom I worked received a letter of inquiry from what was evidently a very peculiar, if exacting, prospective purchaser; his letter read as follows:

> Gentlemen: I am in the market for an uptodate steam engine of two hundred horsepower capacity. It must be uptodate and more economical than the regular Corliss engine kind. If you can build such an engine send your representative.
>
> Yours in haste,

On the face of it, the inquiry looked so good that I went by the next train for an interview. On entering the prospective customer's office, I was surprised to find that it occupied a space of only about ten by sixteen feet and was furnished with a table, holding the upper part of a rolltop desk, in company with two chairs, a letterpress and a peculiar and somewhat shrewd looking man. I include him in the furnishings because he looked cold enough to be one of them.

After going through the usual formalities, he finally asked me to be seated and wanted to know if I was in a position to talk with authority on his proposed installation, carefully explaining that if such were not the case I would waste my time and his also. I assured him that I was there prepared to talk business. He yawned, closed his eyes and wanted to know why engine builders in this country could not get as good economy with compound and triple-expansion engines as they obtained in Europe with single-cylinder units. I tried to tell him he was misinformed, but he slapped his fist down on the desk and warned me not to argue as he knew what he was talking about.

He said he was dissatisfied with the economy they got in Europe even; he wanted something better and had been thinking for a long time of a type that would revolutionize steam-engine practice. Now that he required more power in his stone quarry, he wanted a builder who would incorporate his ideas in the unit. I intimated that a special design (I did not like to say freak design, because it might hurt his feelings—and he was bigger than I am)

would cost much more than one of regular design. He answered that he did not care, as the saving in fuel would soon pay the difference.

He explained that the "thermos bottle" gave him the idea, which was to make an engine having jacket space around the cylinder barrel and heads and instead of using steam in the jackets, to have them connected to an air pump, so as to produce a vacuum and therefore eliminate the transfer of heat between the barrel and the outside and reduce condensation.

I left him with the understanding that I considered him a genius and would try it on the jacketed cylinder of a pumping engine, which I knew I could use for the experiment.

A friend, who is superintendent of a pumping station, gave me permission to use the Corliss engine, and after setting the valves properly, we took some indicator diagrams with the engine running noncondensing and high-pressure steam in the jackets of the barrel and heads. We then connected the vacuum pumps to the jackets and found that with 20-in. vacuum in the jackets the diagrams were not nearly as good as before, and the engine used much more steam in the cylinder when vacuum was used than with the steam jackets.

I wrote the prospective purchaser fully on the subject and about a month afterward received a reply stating that he had just purchased a second-hand slide-valve engine, which I found afterward had been in service about twenty years.

M. E. Griffin.

Franklin, Penn.

Separator Drain as Steam Supply to Pump

In a small plant in Oklahoma the trap on the drain from the steam separator for the 16x36-in. Corliss engine was out of order. I suggested connecting the separator drain as a steam supply to the feed pump and the exhaust from the pump to the open feed-water heater. When this was done we were no longer bothered with wet steam in the engine.

J. Talla.

Mesa, Ariz.

The Fireman Is a Chemist

A good place for a young man to begin his engineering experience is in the boiler room as a manufacturing chemist, for that is what a fireman really is. He uses air composed of hydrogen, oxygen and nitrogen, and coal composed of fixed carbon and hydrocarbons, the latter consisting of olefiant gas, pitch, tar, naphtha, etc. He separates the hydrocarbon from the fixed carbon and endeavors with the means at his disposal to combine one atom of carbon with two of oxygen, and two atoms of hydrogen with one of oxygen, forming respectively CO_2 and H_2O.

In handling the hydrocarbons, he must be careful to supply a sufficient number of atoms of oxygen, otherwise the carbon will form a fine powder called smoke. When this takes place it is usually too late to supply the oxygen and the smoke remains. This visible loss in itself i not so much unless the smoke is deposited on the heating surfaces of the boiler. Then the loss is considerable, as the heat insulating value of soot is about five times that of fine asbestos. Another reason why the fireman must be careful is that if he should combine one atom of carbon with only one atom of oxygen, the heat value, or result in B.t.u. per pound of combustible, will be 4400 instead of 14,500.

But perhaps it is better in these days when encroachments are resented, not to say much about chemistry; the chemists may proceed to brand the engineering profession for their own benefit, and a fireman will then have to be a "D.Ph." and serve some months behind a drug counter.

R. McLaren.

Toronto, Ont.

Trouble with an Air Lift

In the Oct. 6 issue, page 504, Mr. Lacy describes his difficulties with an air lift. The system of piping employed by him is excellent and would afford good efficiency where care is exercised in the selecting of pipe diameters and proportioning the submergence. Unfortunately, both of these important points are often overlooked by engineers. Instances of the difficulties referred to have been brought to the writer's attention a number of times. Of course, it will be impossible to prevent the forming of a precipitate, for this is caused by the oxidation of impurities in the water, but the recurrence of sudden and expensive shut-downs may be prevented by installing the air line as shown in Fig. 1.

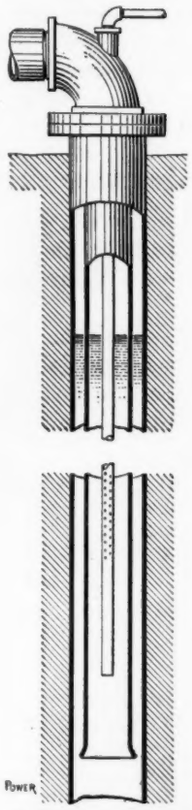


Fig. 1. Perforated Air Pipe with Open End

As indicated, a section of blank pipe is extended below the perforations in the air line and the lower end is left unplugged. Thus any scale or dirt may escape downward and no air will reach the end; instead, it will follow the path of least resistance, which is through the holes. Should a coat of scale form on the inner surface of the air line and gradually restrict and finally clog the perforations, the air will travel down to the pipe end and the well will continue to operate. This condition may be immediately detected on the air gage and the air line may be withdrawn at a time convenient to the operator.

An analysis of the well characteristics and the rather indefinite operating conditions stated by Mr. Lacy, would lead one to believe that the best efficiency is not being obtained. For instance, it is said that the water comes within 30 ft. of the top of the well and that there was 136 ft. of 1-in. air line. It is not stated, however, whether the 30 ft. is the static or pumping head. If it is the pumping head, then as the air-pipe perforations were at an average depth of about 134 ft., the depth of submergence is 104 ft. (134—30 ft.), and neglecting the slight pressure reduction due to established column momentum and the pressure increase due to column friction losses, the operating pressure should be about $106 \times 0.434 = 46$ lb. The actual operating pressure is given as 60 lb.

This means that between the air gage and the lower end of the air line there is a pressure loss of 15 lb., which would seem excessive.

The percentage of submergence was approximately 77 (104 ÷ 134), which is about right, but to this 36 ft. was added, increasing the percentage of submergence to about 82 (140 ÷ 170), which is too high. In this connection it is interesting to note the curves reproduced in Fig. 2. These curves were plotted from results obtained by the writer in a number of tests of the perforated air-line system of pumping. The upper is the submergence curve and is drawn through the points that were found by experiment to be the most advantageous; the lower is the efficiency curve and is drawn through points that repre-

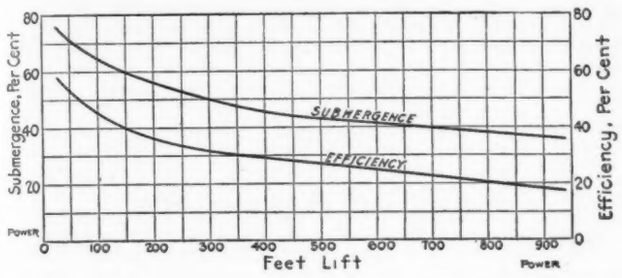


FIG. 2. EFFICIENCIES FOR DIFFERENT PERCENTAGES OF AIR-PIPE SUBMERGENCE

sent the efficiency obtained under various pumping heads when employing the submergence indicated by the upper curve.

These curves must not be understood to be absolutely correct for all cases, as local conditions in any installation may demand a deviation, but they will be a good guide and one cannot be far wrong by following them closely wherever possible.

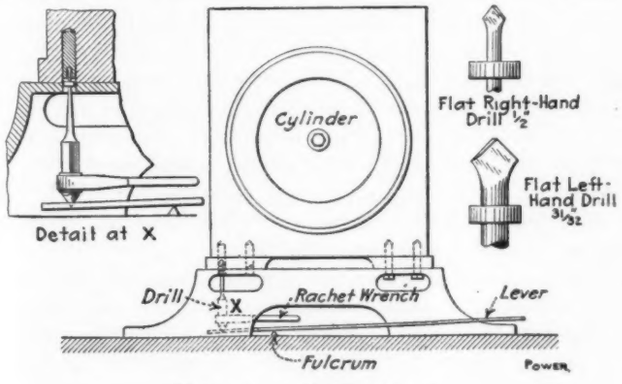
E. M. IVENS.

New Orleans, La.

Replacing Broken Capscrews

A 22x42-in. Corliss engine broke the capscrews that hold the cylinder on the pedestal at the crank end outside, and left about 1½ in. of stubs in the holes.

The problem was to get them out in the shortest possible time. A ratchet drill would not go into the space



DRILL IN A CLOSE PLACE

between the feet and allow the handle to work between the casting and the floor. As we had a ratchet wrench, we had two drills forged with square shanks to fit it. One drill was ½ in. and the other $\frac{31}{32}$ in. (the bolts were 1⅛ in.). We used the ½-in. first, then the $\frac{31}{32}$-in., which was ground to turn to the left. The object was to have the drill tend to loosen the stubs instead of tightening them.

After we had drilled about an inch with the $\frac{31}{32}$-in. drill the stub backed out, leaving a nice, clean thread. We used a long bar and fulcrum for the drill feed. The illustration shows the means employed.

C. L. JUNO.

Milwaukee, Wis.

Air in the Suction Pipe

I have read with interest the article by George H. Gibson on the hundred-million-gallon centrifugal pump for Pittsburgh, in the Nov. 3 issue. Mr. Gibson stated that "due to the small size of the intake and to low water, a certain amount of air entered the suction pipe, probably reducing the capacity and also the duty."

A pump in a plant where I was employed was driven by a cross-compound engine. It had been in service about two months when the testing engineer for the builders arrived and prepared the engine and pump for a test. He made preliminary trials a few days before the official test and knew what duty and capacity to expect. The test was started on the date set and ran for two hours, when the testing engineer called it off, as the pump was not making its duty and capacity on account of air in the suction pipe.

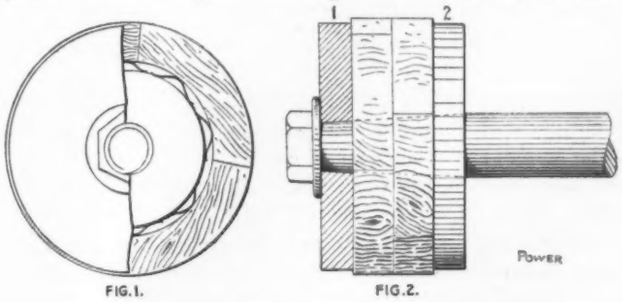
The air leak was around the edge of the seat of a valve that had been connected on the open end of a Y inserted (for future extension) into the suction pipe during the interval between the preliminary and the official test. The record of the test while the pump was getting air showed a decrease in duty of 0.125 per cent., and in capacity of 0.094 per cent.

LAWRENCE KJERULFF.

Kansas City, Mo.

Wooden Packing Rings for Pumps

While few engineers use wooden packing for the water end of vacuum pumps, it is one of the best of packings if properly put in, as the pumps will run with but little friction. It should be made to fit perfectly between plates 1 and 2, Fig. 2. In Fig. 1 it will be noticed that



PLUNGER WITH WOODEN PACKING

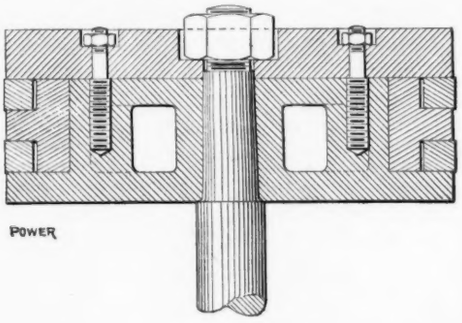
a spring is used for tension on the blocks to set them out against the cylinder walls. This spring is best made of brass ribbon about No. 20 gage in thickness, as it will not rust out like a steel spring. The wood should be hard and close grained, and therefore will not split readily. A set of these rings will last several years if properly made.

C. R. MCGAHEY.

Baltimore, Md.

A Knock Difficult to Locate

In a vertical compound engine running at high speed a severe knock developed. After the engine had received attention at almost all other points the high-pressure cylinder head was removed. The piston was of the built-up type, the follower plate being held in place by six ½-in. studs riveted over to prevent the nuts working off. In this case, however, one of the studs had worked out with the nut, and instead of knocking the cylinder head out



PISTON WITH NEW STUDS

the nut had been crushed, the piston rod bent and the piston loosened, giving it about $\frac{3}{32}$ in. lost motion.

A new rod was ordered, and to prevent another accident all the studs were removed and the ½-in. holes reamed and tapped for ⅝-in. studs; these were reduced at the surface of the piston body to fit the ½-in. holes in the follower plate, which was put on as before and ½-in. nuts used.

Now there is no way for the studs to come out except for all six to work out at once, which is not probable.

EDWARD T. BINNS.

Philadelphia, Penn.

Using a Discarded Feed Pump

On taking charge of this electric plant, I found an old duplex boiler-feed pump that had been discarded. After cleaning the scale and lime out of it, I believed that it could be made fairly good at little expense.

As we had but one pump for feeding the boilers and an injector as a reserve feeder, I set up the old pump and had it on its foundation by the time the superintendent had the new parts. It has two intake and two discharge openings, so I connected one pair to feed the hot water to the boiler; the other intake I connected to the city water and also into the flywheel pit, with shut-off valves on each. When it rains heavily, the water runs into the wheel pit, but we can now pump it out with the steam pump instead of the old pitcher pump. The other outlet has a 1-in. hose connected for washing boilers.

R. F. PETERSON.

Knoxville, Iowa.

Improperly Finished Pumps

Why do pump makers send out unfinished pumps? The writer has five pumps made by one of the best-known American builders and each had to be partly rebuilt, the pins and other parts of the valve motion case-hardened and fitted with grease cups. In a pump situated where there is danger of coal or other dust, if fitted with grease cups the motion work will run for a long time, as the grease prevents dust from getting into the joints, the tendency being to work out at the ends of the bearings and seal them. Again, the stuffing-boxes are, as a rule, shallow and have flat bottoms; also, the gland faces are finished off square instead of being given an angle of about forty-five degrees, which helps to keep the packing up to the rod without undue pressure.

The valve disks, when of metal, are almost always too light and soon buckle up and leak. After new valves have been fitted and steel studs put in to hold the cover on the water end, these pumps do well. The rods and studs are made in large lots on automatic tools from soft, cold-rolled stock, which has very little life in it, whereas for a few cents more, good material might be used.

E. R. PEARCE.

Rochdale, England.

Marking Ammeters

Engineers in charge of alternating-current apparatus furnishing current to systems characterized by a low power factor, as shown by a considerable difference between the "kv.-a." and the "kw." readings, should have the safe maximum limit in amperes marked in red upon all ammeters. This will tend to obviate the practice of operators depending upon the wattmeter readings for the capacity of the apparatus, which is attended with danger on account of the heating effect of the wattless current.

JOHN F. HURST.

Louisville, Ky.

Condition of Some Plants in New York City

On taking charge of a small steam plant in New York City, I found its general condition bad, due to bad management by poorly paid help.

The first things I noticed were poor boiler draft leaky tubes and wasted return water. After repairing the brickwork and leaky tubes, and when all the returns were connected up, one boiler did the work of two. By the use of No. 1 buckwheat instead of pea coal, a reduction of 22 per cent. in fuel cost was made. The refrigerating plant was also in bad shape, a 6-ton water cooler giving only about 200 lb. of water at 40 deg. F. before the temperature went up 6 or 8 deg. Repairs to crankpin boxes stopped the pounding, all expansion valves were set to the pipe coil capacity and freezing back was reduced.

The cooler was next looked over. The inlet was at the top of the head and the outlet at the middle. Consequently, when cold water was drawn it was followed by the warmer water from the upper part of the tank; that is, the tank was upside down. It was turned over and the outlet connected at the bottom, the result being that it cooled 2500 lb. of water from 70 deg. to 40 deg. F. per hour.

The management claimed it could not get good operating engineers, but after a trial of a month, I was then paid 30 per cent. more than the former engineer.

C. W. ROOS.

New York City.

Inquiries of General Interest

Calorific Value of Fuel—What is meant by the calorific value of a fuel?

R. J.

It is the amount of heat or number of B.t.u. liberated per pound of the fuel when undergoing perfect combustion.

Pumping Hot Water—When a pump is to handle hot water, why should the supply be above the level of the pump?

H. G.

So that the water may run into a water cylinder by gravity, for if the supply is placed below the pump, the suction stroke will reduce the pressure on the supply and cause the water to evaporate. The vapor thus given off flows into the pump cylinder, preventing the water from filling the cylinder.

Loss from Incomplete Combustion—What is the difference in the amount of heat realized by burning carbon to CO and to CO_2?

H. D. R.

When carbon unites with oxygen to form CO there are only 4400 B.t.u. given off for each pound of carbon burned, but when the carbon is burned completely to CO_2 there will be given off 14,500 B.t.u. for every pound of carbon burned.

Grades of Steam Pipe—What are the commercial designations of different kinds of steam pipe with respect to pressures for which they are suitable?

G. C.

There are three regular thicknesses or weights, viz.: Standard, which is suitable for pressures up to 125 lb. per sq.in.; extra strong, which is suitable for pressures up to 250 lb. per sq.in., and double extra strong, which is suitable for pressures up to 800 lb. per sq.in.

Grate Surface for Return-Tubular Boiler—What proportion of grate surface should be provided for a hand-fired return-tubular boiler?

R. M.

For developing a fair capacity of the boiler with ordinary chimney draught—i.e., not exceeding about 0.3 in. of water column at the damper and burning anthracite coal or poor varieties of bituminous coals, and with ordinary settings—for a hand-fired grate, not less than 1 sq.ft. of grate surface should be furnished for 30 sq.ft. of boiler-heating surface.

Mercurial Thermometers for Flue-Gas Temperatures—Why cannot ordinary mercurial thermometers be used for obtaining flue-gas temperatures?

J. R.

Mercury boils at about 676 deg. F. and atmospheric pressure, and the ordinary types of mercurial thermometers are unsuitable for measuring temperatures above 500 deg. F. For higher temperatures up to about 800 deg. F., mercurial thermometers are made with the space above the mercury filled with nitrogen gas, and as the mercury expands, the gas is compressed, thereby increasing the pressure and raising the boiling point.

Run Grain Side of Leather Belt on Pulley—Which is the right way to put a leather belt on the pulley? Should the smooth or rough side go next to the face of the pulley, and why?

P. L.

The "hair" or smooth side should go next to the pulley as it is harder and will better withstand the wear from slippage and attrition, besides which the flesh side of most leather belts is stronger at the surface of the leather and placed on the outside will not part or crack so readily. If the smooth or grain side becomes actually worn off it will usually be beneficial in removing the tendency to formation of surface cracks which, once formed, will rapidly extend themselves into the body of the belt.

Capacity of Hydraulic Elevator—If a high-pressure hydraulic elevator is operated with 750 lb. per sq.in. pressure acting on an 8-in. diameter plunger which is geared 6 to 1, would the actual lifting capacity be as great as 3500 lb.?

W. T. O.

The cross-sectional area of the plunger being

$$8 \times 8 \times 0.7854 = 50.265 \text{ sq.in.}$$

and the total pressure acting on the plunger being

$$50.265 \times 750 = 37{,}698.75 \text{ lb.}$$

then, as the elevator is geared 6 to 1, neglecting friction, the lifting power of the elevator would be one-sixth of 37,698.75, or 6283.12 lb. An actual lifting capacity of 3500 lb. would be realized with an efficiency of $\frac{3500}{6283.12}$ or about 56 per cent. With good design, workmanship and materials, and proper adjustment and operation, the efficiency stated should be attained and the actual lifting capacity should be at least 3500 lb.

Value of Constant in Formula for Flow of Steam—What would be the value of K in the formula

$$W = 1.9\,AK\sqrt{(p - d)\,d}$$

sometimes used for finding the weight of steam flowing from a higher to a lower pressure where the lower pressure is greater than 58 per cent. of the higher?

D. P.

Where

W = The weight of steam discharged in pounds per minute;
A = Area of orifice in square inches;
P = The absolute initial pressure in pounds per square inch, and
d = The difference in pressure on opposite sides of the orifice, in pounds per square inch,

then K may be taken as a constant equaling 0.93 for discharge through a short pipe, and 0.63 for discharge through a hole in a thin plate.

Pounding of Engine when Run Condensing—What may be the reason that our 22x36-in. corliss engine cannot be run condensing unless the valves are set with more compression of the exhaust than is required for running the engine noncondensing without pounding?

H. M. J.

With the same valve setting the cushioning effect of compressing the exhaust will be less when running condensing, and in addition there will be a greater tendency for production of a pounding noise from the sudden admission of steam of the same initial pressure into the clearance spaces of the cylinder when filled with exhaust steam, compressed to a lower pressure than when running noncondensing. When there is sufficiently high compression of the exhaust to take up the back lash of the working parts by cushioning, then pounding of this kind will usually be remedied by a more gradual admission of the initial steam, but where this is impractical or undesirable, the remedy is to increase the compression of the exhaust.

Fusible Plugs for Return-Tubular Boilers—How should fusible plugs be made and where should they be located in horizontal return-tubular boilers?

E. C. S.

In most localities where boilers come under governmental regulations the material, form and location of fusible plugs are subjects of special requirements. For a horizontal return-tubular boiler, one or more fusible plugs should be located in the rear head not less than 2 in. above the highest part of any tube, measuring to the center of the fusible plug. The shell for a fusible plug should be made of phosphor bronze or a high grade of brass which will not be affected by the furnace gases, the shell having an external diameter of not less than ¾-in. pipe tap and of sufficient length to project at least 1 in. inside of the boiler and provided with a close hexagon head for setting the plug with a wrench from the outside. The fusible metal should be pure banca tin, the melting point of which is about 445 deg. F., and it should extend the full length of the bronze shell with a diameter of at least ½ in. at the inner end of the shell, and be gradually enlarged at the center or at the outer end of the plug.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Problems in Power-Plant Design--X

Details of Direct Heating, Pipe Mains and Conduits

The principal details relating to direct heating are the methods of computing the radiating surface, types of coil and radiators, systems of piping, location of radiation and connections, and air venting.

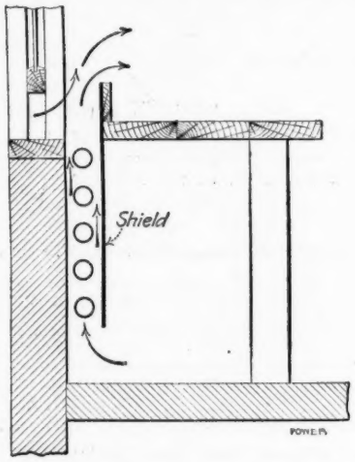


Fig. 1. Good Location for Coils in Shop Heating

Computing Radiating Surface

This is most correctly done by dividing the total heat loss per hour from the room or building by transmission and leakage, as determined by the methods given in article IV, by the heat given off per hour in B.t.u. per square foot of radiating surface. It is common to use 250 for cast-iron radiators and 200 for pipe coils, supplied with low-pressure steam.

When wrought-iron pipe coils are used, square feet of radiation must be reduced to linear feet of pipe, which may be done by use of the following factors:

Size of Pipe, In.	Multiply by
1	3.0
1¼	2.3
1½	2.0
2	1.6

For example, a coil having 100 sq.ft. of radiating surface must contain 100 × 2.3 = 230 lin.ft. of 1¼-in. pipe, or 100 × 2 = 200 ft. of 1½-in. pipe, and so on.

Types of Direct Radiating Surface

In the case of industrial plants the sectional cast-iron radiator is only used in offices, supply rooms and other locations where a comparatively small amount of radiation is required, or where it is desired to keep the larger part of the wall surface free and concentrate the heat in one or more places.

Coils of 1¼- or 1½-in. pipe are commonly used in this class of work, being less expensive to install and distributing the heat more evenly in large spaces. They are most effective when carried along the outer walls beneath the windows, as the heat is delivered near the floor with this arrangement. A specially good plan for a shop is shown in Fig. 1. Here the coils are placed on the walls back of the benches, with a shield in front to prevent the heat from coming out beneath the bench and rising into the workman's face. A space is left next to the wall and the air circulates over the coil as indicated by the arrows.

By opening the windows slightly (as shown) good ventilation may be secured without uncomfortable drafts, as the sheet of hot air rising from the coil mixes with the entering air and carries it upward, thus preventing it from striking directly upon those in front. Coils of this kind are made up with cast-iron headers, and provision must be made for expansion, either by carrying them around a corner or turning the end up and extending it vertically a short distance.

When a single coil will not give the required amount of heating surface in the available space, a double coil may be used, one being placed in front of the other.

Overhead coils are employed when it is desired to keep the walls entirely free, as in storerooms, etc. Heating surface is not as effective when placed in this location, as the heat rises while the stratum of air near the floor remains cold. This, however, is not usually a matter of great importance in the buildings or rooms where this type of coil is used. When employed in occupied rooms, where it is necessary to warm the lower part as well as the upper, it will be necessary to increase the computed surface about 50 per cent.

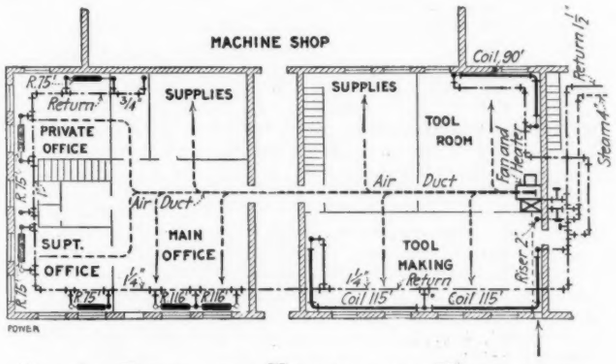


Fig. 2. Piping for Heating and Ventilation—First-Floor Plan, Office Wing

Systems of Piping

When a vacuum system of heating is used it is necessary to provide two connections for coils and radiators, but when run on a gravity return the cast-iron radiators may have a single connection. When a suction is attached to the main return, the discharge outlet from each coil and radiator must be provided with a thermostatic or motor valve which opens only to allow the discharge of air and water, but closes in the presence of steam. Valves of this kind should also be placed on each

drip pipe discharging into the main return. When a vacuum system is employed, all direct radiators in occupied rooms should be provided with a graduated valve so that the amount of steam admitted may be varied to a certain extent and thus make it possible to regulate the temperature of the room. In large rooms the coils are

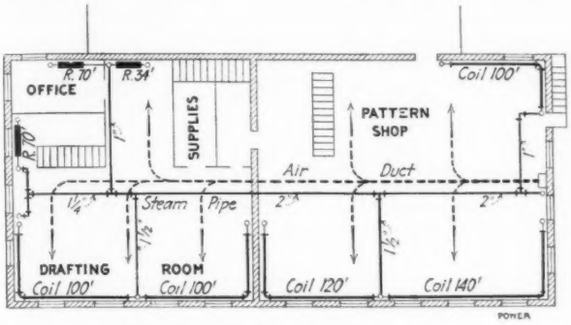


FIG. 3. SECOND-FLOOR PLAN

sometimes arranged in groups, each one of which is provided with a graduated valve and under the charge of a person assigned to its use, and whose duty it is to see that a proper temperature is maintained within the building.

with an overhead supply is shown in Figs. 2 and 3, which represent the first and second floors, respectively, of the office wing of our model plant. The sizes of radiators and coils in the different rooms were computed as previously indicated, the heat loss for the different departments being taken from Article IV. Cast-iron radiators have been used in the offices and some of the smaller rooms, while wall coils have been employed in the pattern shop, drafting room, etc. The steam supply is first carried to the top of the building through a single riser at one end, where it branches and connects with the different supply drops. Each radiator and coil, and the bottom of each supply drop, are connected with the main return through a thermostatic or motor valve.

The return is carried beneath the floor of the first story, but all thermostatic valves in pipes connecting with it should be above the floor so as to be accessible for inspection and cleaning.

The ventilating fan and heater for this section are placed on the floor in the toolroom and supply air at a temperature of 68 or 70 deg. to the different rooms through distributing ducts carried at the ceilings of the two stories. All heating is done by the direct radiation, the warm air being for ventilating purposes only.

This arrangement is employed for this section of the

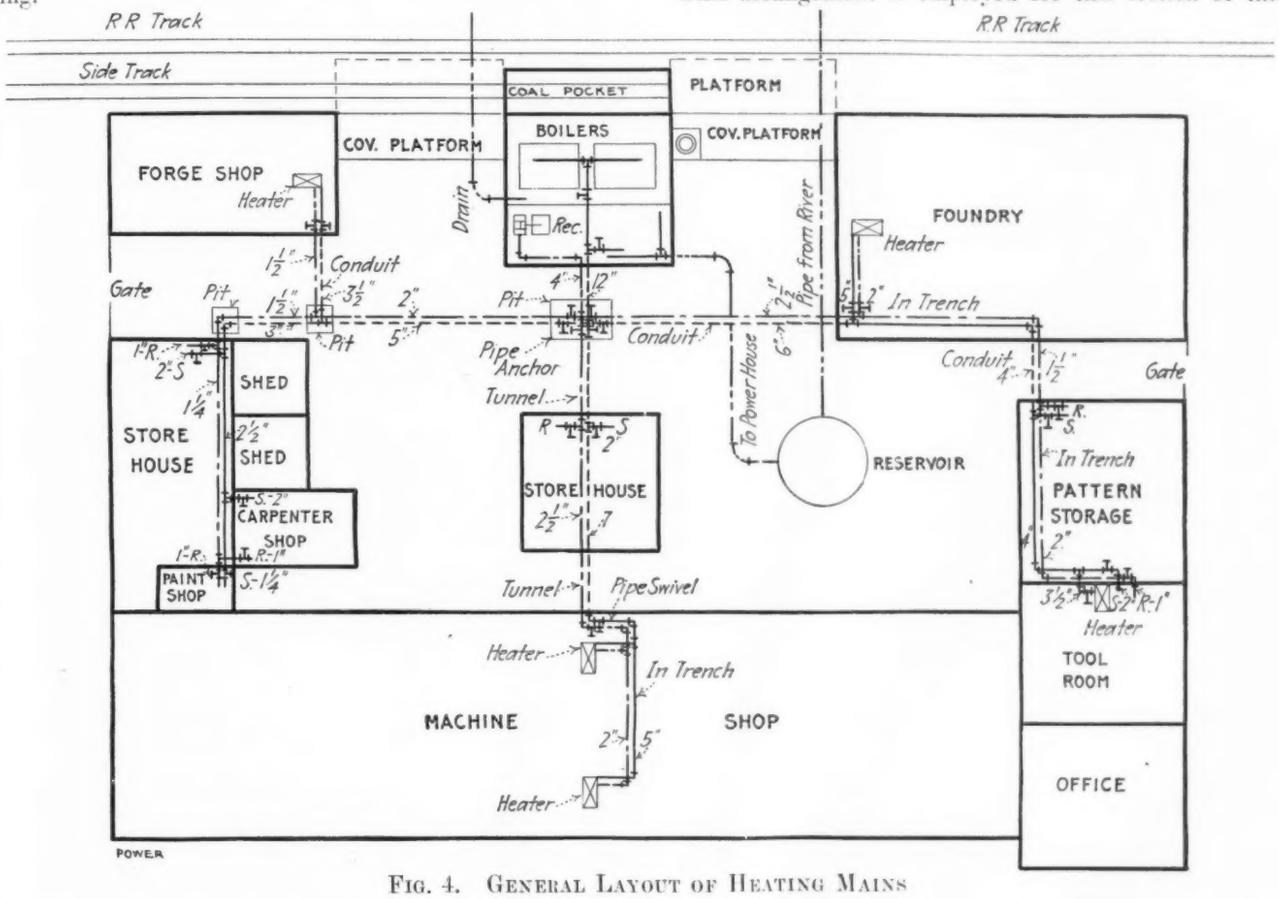


FIG. 4. GENERAL LAYOUT OF HEATING MAINS

With a two-pipe vacuum system it matters very little whether the radiation is placed on an "up supply" or "down supply" so long as the general principle of supply and return is carried out. As many shops have no basement it is usually more convenient to run the supply pipes overhead and carry the returns in covered trenches beneath the floor.

A practical illustration of a system of direct radiation

building because a higher temperature is carried in most of the rooms than in the main shop, and a more accurate temperature regulation is required in the offices and drafting rooms where the occupants are less actively employed. Under these conditions the system is more easily handled for a number of rooms by separating the heating and ventilation as in the present case.

Details of the heating in the carpenter and paint shops,

storehouses, etc., are not worked out. It is assumed that these will be equipped with coils proportioned on a basis of 300 B.t.u. per sq.ft. of surface per hour, and located either on the walls or overhead as found most desirable.

Pipe Mains

A general layout of the pipe mains supplying the different buildings and departments is shown in Fig. 4.

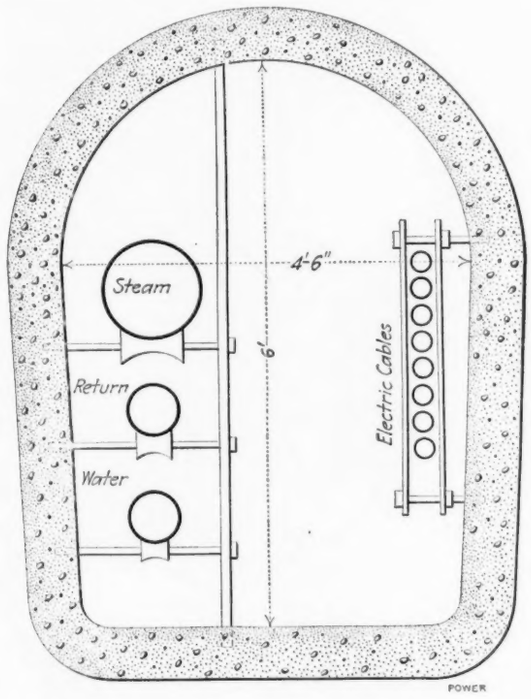


Fig. 5. Section through Pipe Tunnel

Starting at the power house a 12-in. supply main is carried through a tunnel to a walled pit, where it is anchored, and then branches in three directions, one leading to the forge shop, carpenter shop, etc.; one to the foundry and office wing; and one to the machine shop. These pipes are carried underground either in tunnels or conduits as indicated on the plan. Where they pass through the various buildings they are run either in covered trenches or along walls as may be necessary to avoid fixtures and to maintain the proper grade. In the machine shop both pipes are carried across the building in a trench in order to clear the traveling crane.

Expansion is provided for by offsets, and a special swivel just inside the machine-shop wall. Being anchored in the central pit, the mains expand in all four directions, and the increase in length thus being divided into four parts is easily cared for.

Pipe sizes for vacuum systems of the type used in the present case may be taken from Table 1, which applies to lengths of run up to about 400 ft.

The sizes given in Fig. 4 have been taken from this table, which are slightly larger than used by some of the patented systems of vacuum heating.

In the case of a gravity system of heating, where the condensation flows back to the receiver without the use of a vacuum pump, the sizes as in Table 2 may be used for runs up to 400 ft., with steam pressures of 3 to 5 lb. gage.

TABLE 1—PIPE SIZES FOR VACUUM HEATING

Pounds of Steam per Hour	Steam Pipe, In.	Return Pipe, In.
50	1½	¾
120	2	1
220	2½	1¼
350	3	1½
550	3½	1½
800	4	2
1,400	5	2
2,300	6	2½
3,500	7	2½
5,000	8	3
7,000	9	3
9,000	10	4
15,000	12	4

TABLE 2—PIPE SIZES FOR GRAVITY LOW-PRESSURE HEATING

Pounds of Steam per Hour	Steam Pipe, In.	Return Pipe (Dry), In.
60	1½	1¼
180	2	1½
300	2½	2
500	3	2½
800	3½	2½
1,000	4	3
2,000	5	3
3,000	6	3½
4,600	7	3½
6,500	8	4
8,800	9	4
11,500	10	5
18,500	12	5

Tunnels and Conduits

The method of constructing the underground conduits in a plant of this kind is a matter of much importance. In deciding upon the best construction the matter of durability should be considered as well as first cost.

In the present case a tunnel has been provided between the power house and machine shop on account of the large size of the pipes and also for carrying the electric cables. This makes a passageway between the two buildings and provides access to the brick pit where the anchor and main valves in the various branches are located.

A section through this tunnel is shown in Fig. 5 and illustrates the method of supporting the pipes and cables. The walls are of concrete and the dimensions are such that ample space is provided for a man to pass through.

There are four general types of conduits employed

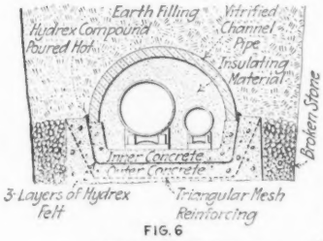


FIG. 6

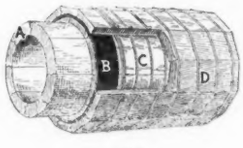


FIG. 7

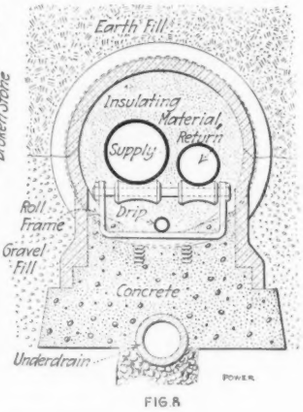


FIG. 8

Underground Pipe Covering

where the pipes are carried underground without means of access; those of wood, cement, vitrified tile, and a combination of tile and cement. Some of the various makes on the market are shown in Figs. 6, 7 and 8.

Fig. 7 shows a wooden conduit which also serves to insulate the pipe. This type requires a separate conduit for each pipe. Fig. 6 shows another form of conduit. This is of combined concrete and tile construction, with special attention given to waterproofing. A split-tile conduit is shown in Fig. 8. In this case both steam and return pipes are carried in the same conduit and the space around them is packed with insulating material.

The life of a wooden conduit depends largely upon the quality of the material, the method by which it is prepared to resist decay, and the amount of moisture in the soil surrounding it. Wooden conduits have been found, in some cases, to be in good condition after 20 years or more of service, while in others they have deteriorated quite rapidly. With the best of material and construction, and proper underdraining, it would seem that the longer period mentioned should be approached in a majority of cases. The best forms of concrete conduit have a life much beyond that of the pipes which they contain. If they are of such form that they must be replaced when the pipes are, there is, of course, no advantage in greater durability. If, however, the pipes may be renewed by simply removing the cover from the conduit, without disturbing the principal part of the construction, as in Fig. 8, for example, durability beyond the life of the pipe becomes an important factor.

Recent Developments in Steam-Electric Generating Stations

On the evening of Oct. 28, John Hunter, chief engineer of power plants of the Union Electric Light & Power Co., St. Louis, gave an interesting address on the above subject at a joint meeting of the Associated Engineering Societies of St. Louis, held under the auspices of the St. Louis section of the American Society of Mechanical Engineers.

Mr. Hunter summarized the equipment of the large generating stations, of New York, Boston, Philadelphia, Washington, Detroit, Milwaukee, Chicago and St. Louis, and amplified his remarks with 110 carefully selected lantern slides. The lecture was so well received that even an abstract should prove of interest. Mention of the various stations has been made in these columns, but a brief review of the big steam plants of the country in one article will bear repetition.

NEW YORK WATERSIDE STATIONS

At present there are 15 different public-service corporations supplying power to the five boroughs of the city of New York. The New York Edison Co., operating the great Waterside stations, is of first interest. Its history of development dates back almost to the beginning of the electric-light industry. The old Pearl St. station, the first Edison electric-lighting station in New York, was built in 1882. Up to the advent of high voltage, alternating-current transmission and distribution, there were numerous steam stations of the non-condensing type for direct-current generation built here and there about Manhattan Island. The Duane St. station is an example. It is made up of 2500-hp. vertical condensing engine units. The first plant of any considerable size was Waterside station No. 1, built in 1900 and designed for sixteen 3500-kw. alternating-current generators driven by vertical compound engines. In 1905, after eleven of these units had been put in, the equipment was completed by the addition of three 5000-kw. vertical turbines and two 10,000-kw. horizontal turbines. In 1911 and 1912 four of the engine units were removed and three 20,000-kw. vertical General Electric turbine units installed. At the same time one of the 5000-kw. turbines was rewound for 9000 kw. The total capacity of the plant is thus 123,500 kw. The station is designed for fifty-four 650-hp. boilers, on two decks and set in batteries of two. The furnace equipment is both Roney and Taylor stokers.

This station was rapidly outgrown and Waterside Station No. 2 was built in 1909. It adjoins the No. 1 station and together, so far as operation is concerned, they are practically a single station, forming the largest steam plant in the world and having a combined capacity of about 215,000 kw.

In No. 2 station the boiler house contains ninety-six 650-hp. Babcock & Wilcox boilers operating at 200 lb. pressure with 125 deg. superheat. Thirty-six of the boilers were originally fitted with flat grates, commonly called straight draft, for hand firing, while the remainder have the Taylor stokers. The boilers are in eight rows across the boiler house, six in a row and on two decks. There are four stacks, each serving 24 boilers, 12 boilers on each deck. There is no railroad track service for these stations, the coal being brought in barges from coal docks in New Jersey. From the barges it is lifted to overhead bunkers and falls by gravity to the boiler hoppers. The ashes are dumped from the pits into cars in the boiler-room basement and drawn by an electric locomotive to a pocket from which they are conveyed to an overhead ash bunker and then dumped into barges for final disposition.

In the turbine room there are six 8000-kw. Curtis turbines, two 8000-kw. Westinghouse turbines and two 14,000-kw. Curtis turbines. Each of the Westinghouse turbines drives a twin generator, one 25-cycle, 6600-volt, and the other 60-cycle, 7500-volt. Either is used as required; they run at 750 r.p.m. The main generating units are equipped with surface condensers, utilizing salt water from the East River for cooling. To provide against a shortage of coal in case of strike or delayed deliveries, the company has a storage yard at Shadyside, on the New Jersey shore, capable of holding 200,000 tons.

INTERBOROUGH RAPID TRANSIT CO.

This New York company also has an interesting history. It furnishes energy for both the subway and the elevated railway lines. The Fifty-ninth Street station, which carries the subway load, is of special interest in that it has five of the largest exhaust-steam turbines in existence. The original installation was completed about 1903 and contained nine 700-kw. Allis-Chalmers (combined double horizontal and vertical, 11,000-volt, 25-cycle). Later, about 1905, three 1725-kw. Westinghouse turbines were installed. Each of these engines had two horizontal high-pressure cylinders 44 in. diameter and two vertical low-pressure cylinders 88 in. diameter, with a common stroke of 60 in. The generators, of the flywheel type, are built of heavy steel plates.

The original boiler installation was fifty-two 600-hp. Babcock & Wilcox water-tube boilers, with space for 20 additional boilers. Eight more were eventually put in.; all are equipped with Roney stokers. Due to the rapid increase in the demand for electric current from this company, the capacity of the station had to be increased. Five low-pressure Curtis turbines of 7500-kw. capacity were installed between and to one side of the reciprocating engines without purchasing additional real estate.

The method used in starting up the combined engine generator and low-pressure turbine is simple and may be of interest. Excitation is applied before starting, then, when brought up to speed, the machine is synchronized in the usual manner. While starting in this way, the induction generator connected to the low-pressure turbine acts as a motor until sufficient steam passes through the engine to carry the turbine above synchronous speed, when it immediately becomes a generator and picks up the load. The leads of the turbine are tied in solidly to the main generator leads through knife switches which are never opened.

The net results obtained by the installation of the low-pressure turbines in this station have been summarized as follows:

- An increase of 100 per cent. in the maximum rating of the plant.
- An increase of 146 per cent. in the economic output of the plant.
- A saving of approximately 85 per cent. of the condensed steam for returns to the boiler.
- An average improvement in economy of 13 per cent. over the best high-pressure turbine results.
- An average improvement in economy of 25 per cent. (between the limits of 7000 kw. and 15,000 kw.) over the results obtained by the engine units alone.
- An average unit thermal efficiency between the limits of 6500 and 15,000 kw. of 20.6 per cent.

In the Seventy-Fourth Street station there are 64 Babcock & Wilcox boilers and the generating equipment comprises eight Allis-Chalmers 7500-kw. combined horizontal and vertical Corliss engines, similar in all respects to the original installation in the Fifty-Ninth Street station, and one 7500-kw. Westinghouse horizontal turbine of the same rating as the engines.

The growth of this company's business again required additional capacity from its generating stations and it has now decided to remove four of the engine units and install three Westinghouse turbines, each of 30,000-kw. capacity. These turbines are cross-compound units. The high-pressure element is a single-flow turbine operating between steam-boiler and

approximately atmospheric pressure. On leaving the high-pressure cylinder, the steam goes through a receiver separator and then into the double-flow, low-pressure cylinder. The high-pressure end operates at 1500 r.p.m. and the low-pressure expansion end at 750 r.p.m.; both ends are controlled by a single governor driven from the high-pressure spindle. The two generators are electrically tied together, therefore, no governor is needed on the low-pressure end. The guaranteed water rate is 11.27 lb. per kw.-hr. Steam enters the center of the turbine through two openings and then divides, one half going each way to a condenser at each end of the turbine.

BROOKLYN EDISON SYSTEM

The tendency of the times is further emphasized by the case of the Edison Electric Illuminating Co., Brooklyn, which operates two main generating stations. Originally the Gold St. station was equipped with four 750-kw. engine-driven generators. At present there are four turbine units having a total generating capacity of 34,500 kw.

BOSTON EDISON

The Edison Electric Illuminating Co. of Boston operates the largest central-station plant and distributing system in New England, and supplies 31 cities and towns with electrical energy, serving an area of 466 square miles and a population of about 1,250,000. The point must remote from the main generating station is Hopkinson, 43 miles away.

The L St. plant consists essentially of two separate stations so far as the building and generating equipment are concerned. The two divisions of the plant are officially designated as Station 4-1 and Station 4-2, but they are electrically connected through suitable transforming and switching apparatus to serve the alternating-current system in common. The stations are radically different in type, representative of the state of the art at the periods of their respective construction. Station 4-1 contains 12 Babcock & Wilcox boilers rated at 550 hp. each, operated at 160-lb. steam pressure and supplying six 1500-kw., 60-cycle alternators directly connected to vertical cross-compound McIntosh & Seymour engines. All of the boilers in this station are equipped with Hawley down-draft furnaces and are hand fired. There is one stack 11 ft. 6 in. diameter and 225 ft. high.

Station 4-2 at present contains ninety-six 500-hp. boilers set in 12 rows of batteries. For the peak load in December, 1908, the available generating equipment in this station comprised four G. E. Curtis turbine units of 5000 kw. each, and one 8000-kw. unit of similar make. In 1909 two of the 5000-kw. units were replaced by 12,000-kw. sets, all of 60-cycle, 6900-volt design. The second pair were 7500 kw. each, the fifth unit 12,000 kw. and the sixth, seventh and eighth of 15,000 kw. each, making a total of 96,000 kw. The improved economy of the larger size and later design of turbine, combined with the modern practice of getting from 200 to 300 per cent. rating out of boilers at peak loads, enabled this increase in turbine capacity to be made without increasing the boiler capacity. The original design called for eight 500-hp. boilers to one 5000-kw. turbine, and there were eventually to be 12 of the 5000-kw. units.

Coal is removed from vessels by two movable steam hoisting towers to a belt conveyor running beneath them on the wharf, elevating it some 50 ft. and conveying it to the trestle alongside of the storage yard. Two traveling bridges, each having a large grab bucket, distribute the coal from the trestle to the yard, or reclaim it from the yard and deliver it to the belt conveyor system from the bunkers above the boilers. The conveyor system from the yard to the boiler house is in duplicate.

PHILADELPHIA ELECTRIC CO.

This company has two main generating plants, stations A-1 and A-2. Station A-1 is equipped with turbines varying in size from 7500 kw. to 15,000 kw. For this station a 35,000-kw. General Electric turbine is now being built. While it is 5000 kw. larger in capacity than the Westinghouse cross-compound turbine, it is contained in one unit and involves special characteristics recently developed by the General Electric Co. To permit of greater mechanical stability and to provide greater area in the low-pressure end, the casing is divided into two parts with a bearing between. The revolving field is an enormous steel forging, with milled slots, similar to small machines. The armature frame is cast in two halves, each of which represents about the limit of casting and transportation possibilities. The turbine and generator are mounted on a common base, thus constituting a single generating unit, in this respect surpassing anything else heretofore attempted.

WASHINGTON PLANT

The Bennings plant of the Potomac Electric Co. is on the Potomac River and supplies electric energy to the city of Washington, D. C. It is a modern and highly efficient all-turbine station of 37,000-kw. capacity, there being three 8000-kw. and two 5000-kw. units. All of the units generate 6600-volt, three-phase, 25-cycle current. The energy is transmitted underground to the company's substations.

In the boiler room there are twenty 600-hp. Babcock & Wilcox boilers and four 525-hp. boilers. Twenty of them are equipped with Roney stokers and four with Taylor stokers. This station was built in 1906 and thus far has had a successful existence. The station output has steadily increased from a little over 29,000,000 kw.-hr. in 1907 to 101,000,000 kw.-hr. in 1913; 44 per cent. of the station output is for lighting and the remainder for railway service.

PLANTS OF THE DETROIT EDISON CO.

Delray plants Nos. 1 and 2, are four miles southwest of the business center of Detroit, on the banks of the Detroit River. No. 1 station, built in 1904 and containing four 3000-kw. units, now has four 8000-kw. Curtis turbines. No. 2 station, built in 1908, has three 14,000-kw. and one 15,00-kw. turbines, making the turbine rating of the two plants 89,000 kw.

The output of the Delray plant is delivered for the most part to customers of the Edison Illuminating Co in Detroit, although an extensive suburban district is also supplied through the Eastern Michigan Edison Co. There is also a 50-mile transmission line connecting the station with the town of Memphis, Mich. About one-fifth of the station output is supplied to the Detroit United Railways Co.

The original design of the No. 1 plant included a surplus of boiler capacity for the purpose of permitting the four original 3000-kw. Curtis turbine sets to operate noncondensing. The exhaust steam was to be supplied to salt refiners in the vicinity for evaporating the brine. Twenty-four 500-hp. Stirling water-tube boilers were installed, set in four atteries of six each. Each boiler contains 4834 sq.ft. of heating surface. The second bank of tubes forms the superheater with an area of 1500 sq.ft. and superheating to 600 deg. F., or 200 deg. F. above the normal temperature of the steam at 210 lb. per sq.in.

The first four turbines in station No. 1 were run condensing. The plan for supplying exhaust steam to the salt refiners was never carried out because the company's load had so increased that it was found necessary to install an additional 3000-kw. unit; this was done without increasing the boiler equipment.

The first four 3000-kw. machines of 1904 were replaced in 1911 by 8000-kw. units of similar type; they were equipped with Worthington 16,000-sq.ft. surface condensers of the base type.

The No. 2 turbine room has three 14,000-kw. and one 15,000-kw. vertical Curtis General Electric turbine units, which, like the machines in No. 1 turbine room, furnish 4600-volt, 60-cycle, three-phase energy. The turbines are ventilated by forced draft and the dampers are so arranged that air can be taken from the engine room and delivered to the outside, or, as is desirable in winter, the outside air can be taken into the machines and delivered to the engine room.

Of special interest in connection with the Delray plants are the nine big double-fired Stirling boilers in No. 2 power house, each having a rated capacity of 2365 hp. The normal output is 7000 kw. in regular service and they have been drawn upon for 11,000 kw. during short periods. All are equipped with Taylor stokers, which have a nominal area of 300 sq.ft., with a heating-grate ratio of 79 to 1. The steam pressure carried in this plant is 205 lb., with 150 deg. superheat. This was one of the first stations to develop high superheat. The original steam fittings were cast iron and had to be changed to steel after five years, weakness in the iron having developed. The superheaters are mounted between the boiler tubes proper.

Each of the 54-in. steam drums has eight 4½-in. safety valves besides four 3-in. on the superheaters. The advantages in the use of these large units are found in a decreased cost per horsepower of rating; a lower radiation loss per unit of capacity, hence a higher efficiency, and they occupy smaller area per unit of output. Repairs on these larger units are not excessive and do not exceed the usual cost per horsepower with small-sized units. The combined boiler and furnace efficiencies obtained run from 80 per cent. at 75 per cent. rating to 76 per cent. at 200 per cent.

With the city's phenomenal growth and demand for electric energy, the Detroit company has under construction a 100,000-kw. plant at Connor's Creek, which is at the opposite end of the city. This plant is expected to be completed to take the fall load of 1915.

PLANTS OF THE COMMONWEALTH EDISON CO.

By far the greater part of the electrical energy generated by the Commonwealth Edison Co., in Chicago, is produced at the Fisk St. and Quarry St. stations, which are on the south

branch of the Chicago River. The engine room of the Fisk St. plant is 630 ft. long and was originally designed for fourteen 5000-kw., vertical Curtis turbine units. The first unit was installed in 1903, but later it was decided to use 12,000-kw. units instead of 5000. One of the 12,000-kw. units had been installed when the advance in the art led the company officials to decide that the last four units should be of 20,000-kw. capacity, or larger, and of the horizontal type. Of these, two are already installed, one a General Electric 20,000-kw. and the other a Parsons 25,000-kw. turbine.

The boiler house of the Fisk St. station was originally designed for 14 batteries of eight 500-hp. boilers, and 10 of these batteries, comprising 80 boilers, are already in use. The remainder of the boiler house will be filled with four batteries, each of four boilers and each boiler having 12,250 sq.ft. of heating surface, with an equipment of economizers and induced draft fans with which, it is anticipated, the boilers can be worked at 200 per cent. of rating. The combined generating capacity of all the units at Fisk St. is 165,000 kw. When running at full capacity the station will consume nearly 2000 tons of coal a day, and nearly 200 tons during the maximum or peak hour. The number of heat units required to generate a kilowatt-hour with the old equipment was approximately 28,000; with the new equipment it is something less than 20,000. This would be two pounds of coal at 10,000 B.t.u. or 1.43 lb. at 14,000 B.t.u.

The great increase in the business of the Commonwealth Edison Co. made it necessary to build the Quarry St. station in 1908. The two stations are operated together as one electrical generating station, being connected by tie lines in two tunnels.

Arranged in two rows parallel to the turbine room are eight 500-hp. water-tube boilers for each generating unit, or 48 for the entire station. The original boiler setting at Quarry St. was a departure in furnace design in that the furnaces were placed under what is usually considered the rear header. In other words, the slope of the tubes was up and away from the furnace rather than the reverse. The advantage sought was in the long combustion chamber, expanding in volume, which made for more complete combustion of the fuel and an increase in boiler efficiency. These boilers were equipped with horizontal passes. After a time it was found that the maintenance costs were running high, and it was decided to equip the last six of the boilers with standard settings, although at the same height as the other; this gave a larger combustion chamber than is the usual practice. The station has eight 12-ft. steel stacks, 250 ft. high, each stack serving six boilers.

Eight boilers are independently connected to each of the six turbines, although cross connections are available in case of emergency. Each of the turbines has its own independent auxiliaries, including a hotwell pump, a combined circulating and vacuum pump, a feed-water heater and a 4-in. three-stage centrifugal feed pump. Quarry St. was the first station in the United States to install centrifugal boiler feed pumps.

The rate at which the business of the Commonwealth Edison Co. was increasing made it evident in 1910 that the Fisk and Quarry St. stations would be inadequate for the service and plans were immediately made for additional station equipment. The new Northwest Station has been the result. Between 1908 and 1910 the maximum load on the system grew from 117,370 kw. to 182,600 kw., an increase of 55½ per cent. In 1912 the maximum load had further increased to 200,000 kw. In planning for the capacity of the new station the indications were that for a number of years the increase would average at the rate of 15 per cent. per year. This rate of increase, applied to the load of 200,000 kw. in 1912, indicated that the net increase of load during the following five-year period would amount to 220,000 kw. Accordingly, plans were made for two new power houses of 220,000 kw. each, it being considered advisable to prepare for more than five years' growth. A location was therefore selected which would be suited to the many and great requirements of such an equipment. To supply fuel for an aggregate of 240,000 kw., or 350,000 hp., requires something like 4000 tons of coal per day, or 100 car loads. Inasmuch as the fuel has to be brought 200 miles by rail for the Chicago plants, a reserve supply of even four days, if held in cars, would mean four miles of track room for 400 cars. The coal strikes, which occur quite regularly every two years, however, frequently mean that no coal can be had from the mines for three months. Hence one of the demands of the new plant was that there must be sufficient storage for coal to carry the stations over a three months' interval — that is, storage room for 350,000 tons. The site of the new Northwest station was therefore chosen at a point on the north branch of the Chicago River, several miles from the Fisk and Quarry St. stations, where sufficient acreage for coal storage was available.

The boiler house is so designed and equipped that at no point in the handling of the great volume of coal that daily passes through it, is it necessary to use manual labor. The boilers are arranged in rows of ten each, facing each other on opposite sides of a common firing aisle, so that one set of firemen and water tenders can look after twenty boilers. Each ten boilers are served by a tile-lined steel stack, 17 ft. inside diameter and extending 275 ft. above the boiler-room floor. When completed the turbine room will be 290 ft. long with the five turbines spaced on 44-ft. centers. The first two turbines are of the vertical Curtis type, similar to those at the Fisk and Quarry St. stations, and are rated at 20,000-kw. capacity, with a steam consumption of 13.45 lb. per kw.-hr. at the most efficient load, namely, 15,000 kw. The additional units for this plant are expected to be of the horizontal type and may run in capacity to 30,000 kw. or more.

COMMERCE STREET STATION, MILWAUKEE

The generating capacity of this station is 61,900 kw. The development of the plant has been in three periods. The first installation was in 1902 and consisted of four 1500-kw., engine-driven, 25-cycle units equipped with barometric condensers and eight 650-hp. boilers equipped with Jones underfeed stokers.

In 1905 four more engines were added, driving 2000-kw.; 600-volt, direct-current generators, and eight additional 708-hp. boilers. Shortly after this two 1000-kw., 60-cycle vertical General Electric turbo-generators were installed. In 1911 the final additions were made which have brought the plant into practically its present condition. At this time all of the barometric condensers of the original installation were removed and the two 1000-kw. turbines taken out.

For increasing the capacity of the plant two 7500-kw., low-pressure, 25-cycle turbines were added to operate in series with the reciprocating engines, similar to the installation in New York, and also two high-pressure, 14,000-kw., 60-cycle vertical turbines. Along with this increased generator capacity eight additional 765-hp. boilers and auxiliaries were installed. Since then a 4500-kw. 60-cycle turbine has been put in.

The steam supply for the low-pressure turbine in this station is taken from the exhaust of seven reciprocating engines, all exhausting into a common header and supplying steam to the turbines at 16 lb. initial pressure. The receiver separator taking the steam from the engines is the largest steam separator in the world, being 10 ft. in diameter and 22 ft. high.

The effect upon the steam economy of the installation of low-pressure turbines was marked. It was estimated that about one kilowatt-hour of energy could be obtained from the low-pressure turbine by the use of steam exhausted from the engine while delivering one kilowatt-hour, thus getting two kilowatt-hours of energy for the water rate of one kilowatt-hour on the engines noncondensing. The latter rate was about 30 per cent. higher than under condensing conditions. The overall water rate would thus be changed in about the ratio of 22 to 16 lb. per kw.-hr.

The total rated capacity of the 24 boilers in the Commerce St. station is 16,984 hp., or one boiler horsepower for each 3.64 kw. of installed capacity. Operating conditions, however, are in the ratio of one boiler horsepower for each 1½ kw. of installed capacity. There are 12 stacks, each 8 ft. in diameter and 100 ft. high, each of which serves two boilers.

ST. LOUIS PLANT

There are few plants throughout the country that show development more clearly than does the Ashley St. station of the Union Electric Light & Power Co. The original units were 3000-kw. Allis reciprocating engines. These units are still in place, but are utilized for emergency operation only. Next came the 5000-kw. turbine units which were replaced by the 12,000-kw. Curtis turbines. Four of these units were installed upon the same foundations and with the same auxiliary equipment that had been used for the 5000-kw. turbines. This change increased the generating capacity of the station from 36,000 kw. to 64,000 kw., an increase of 78 per cent., and at the same time reduced the steam consumption on the turbine generating units from 21 to 15⅛ lb. per kw.-hr., a reduction of 26.2 per cent. Subsequently, two 2000-kw. vertical Curtis turbines were replaced by two 4000-kw. horizontal Curtis turbines.

Preserve Original Trial Data—On installing new machinery, the results of the initial trials should be recorded and filed for reference. Duplicate copies of these results should also be made. It is of value to know the conditions under which a boiler, engine, pump or other apparatus worked when new, for comparison with later tests and trials.

Prize-Winning Regulating Device

Our readers will recollect the photographic contest inaugurated in July by the Mason Regulator Co., and which closed Nov. 2. The aim was to obtain photographs and data of its devices which were performing some unusual duty. The following have been announced as winners of the $25, $15, $10 and two $5 cash prizes, respectively:

H. N. Downs, Shelton, Conn.; George Van Vleck, Rochester, N. Y.; W. H. Odell, Yonkers, N. Y.; C. Cooper, Portland, Ore., and A. H. Cutler, Putnam, Conn. Ovide Vachon, Beauport, Que., Can., received a special prize of $10, he having submitted a drawing which debarred him from the photographic contest.

The judges were F. L. Fairbanks, chief engineer, Quincy Market Cold Storage & Warehouse Co., Boston; E. H. Kearney, past-president, National Association of Stationary Engineers, and Albert C. Ashton, treasurer of the Ashton Valve Co., Boston, Mass.

The winner of the first prize, H. N. Downs, is employed as an operating engineer at the plant of the Sidney Blumenthal Co., Shelton, Conn. The arrangement which captured the largest prize money consisted of a Mason steam pump speed governor mounted on an 18 and 16 by 24-in. double-acting Davidson pump (Fig. 1), which supplies water to a gravity tank located approximately 20 ft. above the ground level. Before entering the tank the water is forced through two Roberts pressure filters, connected in multiple, and having a capacity of 1,000,000 gal. per 24 hr.; the water is used for dye-house purposes.

The pump is controlled by the speed regulator so as to avoid forcing the filters in case of variable steam pressure. In series with the balanced valve used wtih a speed governor is a second balanced valve, operated by a float in the tank (Fig. 2). The tank is 16 ft. high and the float is set so that it does not begin to operate until there is 12 ft. of water in the tank, when the balanced valve A is gradually closed by the action of the float, thus partially shutting off the steam supply to the pump, and making the filter plant prac-

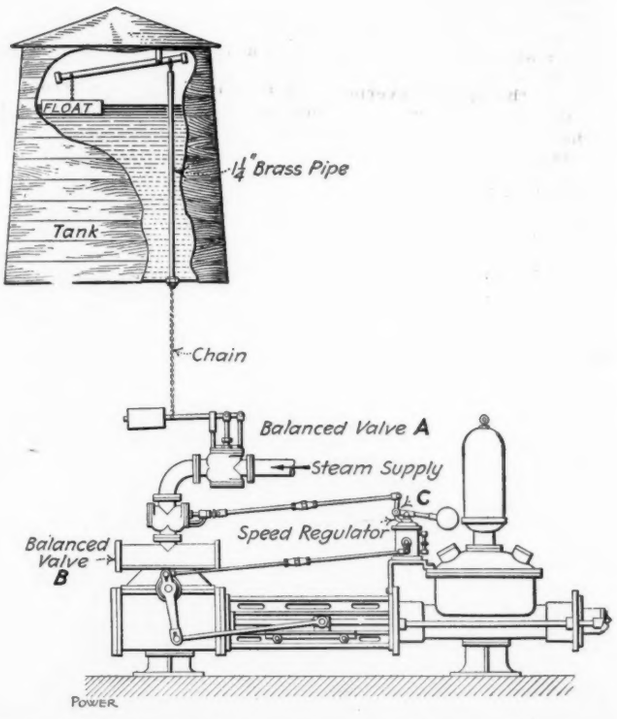


FIG. 2. SHOWING ARRANGEMENT OF SPEED REGULATOR AND BALANCED VALVES, THE TOP ONE BEING CONTROLLED BY THE TANK FLOAT

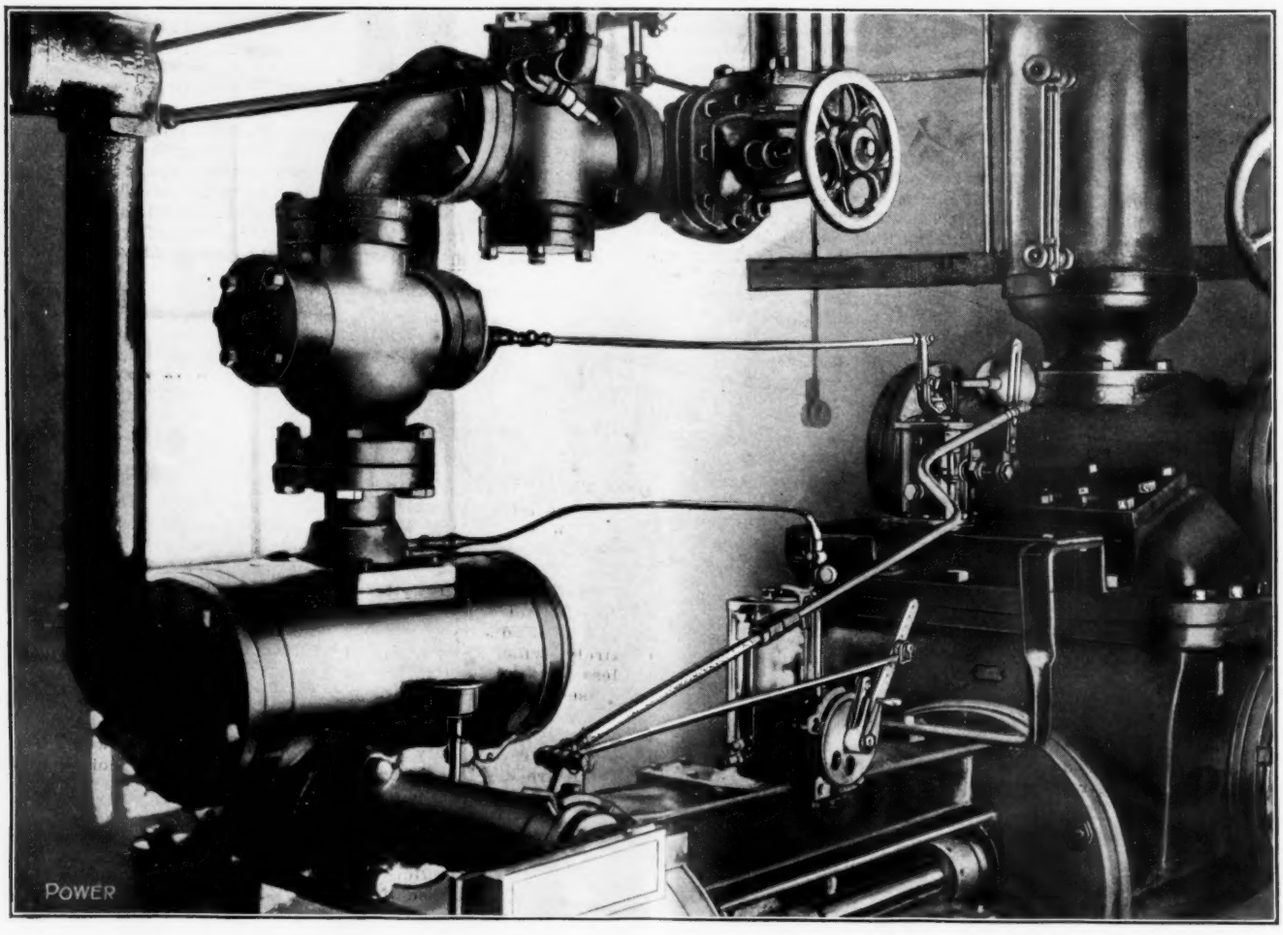


FIG. 1. ILLUSTRATING THE APPARATUS WHICH WON THE FIRST PRIZE IN THE PHOTOGRAPHIC CONTEST

tically automatic in operation. When the water level reaches a height of 15 ft. in the tank the steam is shut off. For the float a small gasoline tank was used, and to assure positive action the float lever has a ratio of approximately 10 to 1.

When the speed governor was first installed some trouble was experienced because the float-operated valve would open as the tank emptied, allowing the steam pressure to act on the piston of the pump, causing it to race until the speed governor gathered sufficient oil pressure to build up and govern the pump. This was overcome by putting on an adjustable bracket under the lever which holds it up in practically its operating position, and thus allows the pump to accelerate properly.

Flywheel Explosion at Iola, Kan.

On Oct. 27, at about 1:30 p.m., the flywheel of a 400-hp. engine exploded at a plant where about five hundred men were employed. The explosion threw pieces of the wheel over 1000 ft. away, wrecked one corner of the engine room and left nothing but the hub and a part of one spoke on the shaft.

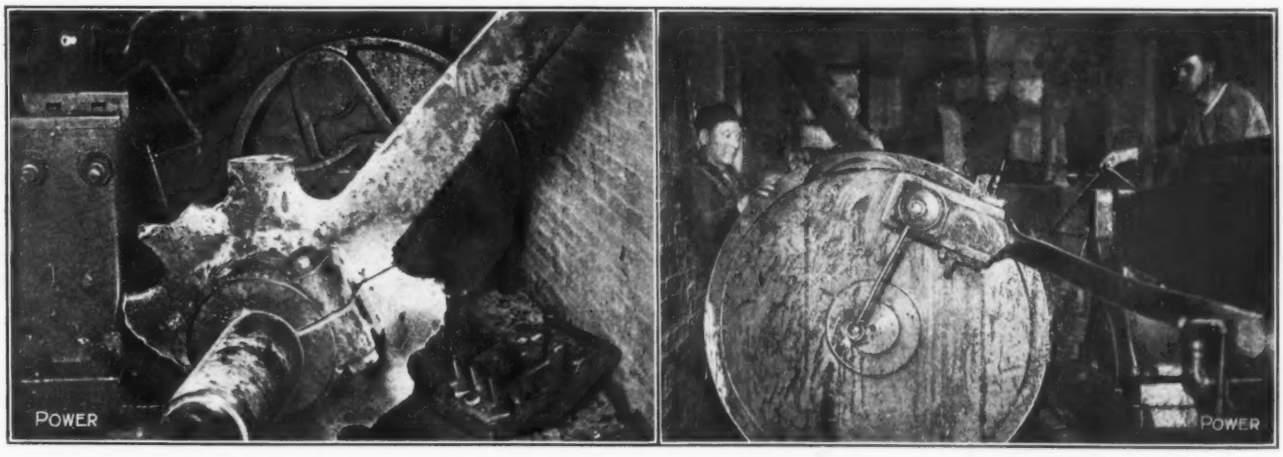
The cause of the accident was overloading the 34-in. three-ply leather belt driving the lineshaft, it being broken in several pieces.

The cast-iron flywheel weighed six tons and was 14 ft. in diameter and had a 36-in. face. It was cast in two parts and bolted at the hub and rim; all of the bolts held. The wheel ran normally at 105 r.p.m.

The largest piece weighed about three hundred pounds. A 215-lb. piece was thrown over the rock bins and landed on the laboratory building. Other parts were scattered over the factory grounds and buildings. The driven and tightener pulleys were broken in small bits.

The illustrations show the hub, shaft and disk, also the bent connecting rod. These parts weighed about four tons and were thrown against the wall. The 400-lb. cylinder head was blown forty feet away and against the rear wall.

Although eight men were in the engine room at the time, exclusive of the 500 men about the plant, no one was hurt.



Result of a Flywheel Explosion

Effect of Washing Kansas Coal

Before the Kansas Gas, Water, Electric Light and Street Railway Association, A. A. Potter, dean of the division of engineering and professor of steam and gas engineering at the Kansas State Agricultural College, read a paper on the above subject. The results, as expressed in the paper, are briefly given in the following:

The coal was washed to remove the clinker formative impurities. This was accomplished by running the coal through a washer or tank filled with water. The water in the tank was given a pulsating motion, forcing the coal to the surface and allowing it to be carried away by the water. The impurities, which were heavier than the coal, settled, and were removed by a conveyor.

To determine the effect of washing Kansas coal, three representative carloads of coal were selected at the mines of the Kansas state penitentiary at Lansing, Kan. Samples of the coal for chemical analyses were taken at the mine and at the cars. One of these test cars was sent to Manhattan, Kan., as mine-run coal and boiler tests were conducted with it at the engineering laboratories of the Kansas State Agricultural College, using hand-fired as well as stoker-fired boilers. The second test carload of coal was crushed and then tested at the college in a similar manner. The third carload was also crushed and washed at the washery of the Central Coal & Coke Co. The washed coal was then tested at the college.

EFFECT OF WASHING ON CHEMICAL COMPOSITION

1. The ash and other noncombustible material was decreased 45.8 per cent.
2. The sulphur in the coal was decreased by 50.1 per cent.
3. The fixed carbon was increased by 7.3 per cent.
4. The heat of combustion per pound of fuel was increased about 22 per cent.

EFFECT OF WASHING ON BOILER OPERATION

1. The total ashes handled in the case of washed coal was 22.7 per cent. less than in the unwashed, all other conditions being the same.
2. The evaporation of the boiler in pounds of steam per hour from and at 212 deg. F. was increased by 23.6 per cent.
3. The evaporation of the boiler per square foot of heating surface was increased by about 20 per cent.
4. The capacity of the boiler in boiler horsepower was increased by 20 per cent.
5. The total efficiency of the boiler, furnace and grate was increased 10.7 per cent.

During the tests it was evident that the firemen had much less difficulty in keeping up the steam pressure with the washed than with the unwashed coal. The reduction in the sulphur eliminated the formation of bad clinkers and decreased the frequency and labor of cleaning fires.

In general, the results of both the chemical and the boiler tests showed that considerable saving can be effected by washing coal if the coal contains much clinker formative material.

Electricity in Manufacturing

"Electricity in Manufacturing" was the subject discussed at the recent meeting of the New Haven Section of the American Society of Mechanical Engineers. The first speaker, Prof. C. F. Scott, pointed out that industry is essentially the transformation of materials from the raw state to a useful product which involves the combined efforts of labor and power. Industry in its beginning employed human labor entirely, which was later replaced by the engine and an endless array of belts and shafting. Present industry replaces these with a new link between the engines and the actual working machines, namely, the dynamo, with ramifying wires to motors of all descriptions. This not only replaces but adds to the variety of operations and use of power. Thus there are electroplating baths, electric furnaces, hoists, magnets and factory and office lighting, all of which are obtainable from the same source.

A review of the industries of the United States since 1870 shows the population to have doubled in about thirty-three years, the value of manufacturing products in sixteen, the horsepower used in even less, while since 1890 the electrical horsepower has increased by leaps and bounds, doubling in three or four years.

Locally, Connecticut has a number of companies operating

central stations which furnish power to manufacturers. Of this power, a large amount is alternating current, testifying to its utility in operating machinery. These companies are rapidly replacing steam units, the average motor sizes running from 10 to 25 hp., with a maximum of 250. The central station, which makes a specialty of generating power, in Professor Scott's opinion, is often able to do this much more cheaply than individual manufacturers, and at the same time will save the latter the bother incident to looking after their own plants.

If the relative costs of material, labor and power are compared, it will be found that material and labor are usually of the same magnitude, whereas the power item is relatively small. Taking the labor cost for one day, the corresponding power cost is equal to the labor cost of half an hour, the light bill to that of five minutes, and the interest on the money invested in the motor, and repairs, to that of one minute.

The power cost proving to be relatively small, the aim of the manufacturer should not be essentially to save power, but to utilize it to the highest degree possible to do part of the work which labor at present must perform, or, by time-saving applications, to make that labor more efficient and increase the production or quality. It may also effect a saving in the material used, by improved methods or processes or by certainty of operation. "Its very flexibility and adaptability," said Professor Scott, "must make electricity a valuable agent in transforming materials."

W. L. Merrill, of the General Electric Co., next presented an illustrated lecture on "Mechanical Methods of Motor Application," the underlying argument being that the manufacturer of a product must coöperate with the electrical manufacturers, and both of these with the builders of machinery used in the industry. With regard to individual drive, he pointed out that simplicity and the elimination of duplicate parts for producing a given operation are necessary for its perfection. As a rule, the more direct and closer the motor, the greater the efficiency. Many slides were shown to emphasize where and where not to put motor drives. In particular, high overhung motors are undesirable as is also any location leading to much vibration.

In the discussion following, Mr. Flynn, of Hartford, told of using electricity in bake ovens for typewriter machines after japanning. Electricity, purchased from the Hartford Electric Light Co. at the extremely low price of 0.9 cent per kw.-hr. was responsible for a saving of 10 per cent. per machine baked with much greater certainty of the result.

Other points emphasized in the discussion were, that, with electricity, to pull the switch is to cut off the expenditure at once; that the flywheel inertia of pulleys, shafting and belts is often needed, but is many times forgotten in applying motors; that with motors directly applied, quick starting and stopping sometimes cause considerable strain on shafts and bearings in view of which the question was raised as to whether a belt is not sometimes good in the capacity of a safety valve.

At the evening session S. J. Morgan, of Boston, read a paper on "The Electric Motor in Manufacturing Plants," pointing out that the keynote of progress is time, or rather the intensified use of time, for in progressive manufacturing it is necessary to use every second out of the sixty and that at maximum speed. For example, the cutting time on many machines is only one-third of the total used on a piece, the balance being consumed in making adjustments; consequently the cutting time must be used at maximum efficiency.

The speaker next considered various styles of drives, recommending in general the individual drive. This may be more expensive in some cases, but the extra cost may be paid in a comparatively short time by the saving in power and friction load.

Damages for Loss of Water Power

In a paper before the American Society of Mechanical Engineers, F. W. Dean, of Boston, discussed the subject of damages for loss of water power when a stream is diverted and suit is instituted by mill owners whose plants are located below the point of diversion. In such cases the value of the water power diverted is generally determined by the cost of making the power by steam, the actual value being the capitalization of the saving effected by the use of water.

On the one hand, power can be produced by a steam plant, and on the other, by water power combined with steam to produce a uniform supply throughout the year. If the annual charges (fixed and operating) of the steam plant exceed those of the water plant and auxiliary steam plant combined, the water power has value, but if less it has no value.

The theory in a suit of this kind is that the award shall be such that the interest thereof shall be sufficient to equal the extra expense caused by the diversion. This rate is usually taken as 5 per cent., although this is often the subject of argument.

As pointed out by Mr. Dean, water powers are seldom developed to the full capacity of the wet months, it being customary to develop to the average power of the eighth or ninth month of the year, when the stream flows are arranged in the order of wetness. In this connection it might be remarked that the calendar order is without significance.

A water power produced by the unassisted flow of a stream is of little value when developed to the customary extent. It frequently happens, however, that areas are available in the watershed that can be dammed, and overflowed in the wet months so as to be used to make up to some extent the deficiency in the drier season. This is usually done, and is a saving feature of water-power development, but it probably in no case results in a uniform power supply. In such developments as those at Niagara and Keokuk, steam plants are not necessary because the power required for a long time will be below the minimum flow, and especially at Niagara, which for scenic reasons will probably never be developed to use the minimum flow.

AUXILIARY STEAM UNITS

The most economical engine to install depends upon the power to be made up to produce a steady supply. Between certain limits, the author expressed the belief that the simple non-condensing type was the most economical. Beyond this, and up to a certain other power, the simple condensing engine should be used, and still further the compound condensing engine if necessary. Similar arguments apply to condensing and non-condensing steam turbines. The points to be considered are those producing the greatest net economy as made up of fixed charges and costs of operation. In every case, an engine should be selected that will be well overloaded in the driest average month and much underloaded in the wetter months; and the requirement of the months of the driest year should also be considered.

In damage cases much testimony is given concerning the economy of steam plants. It is well known that such economies are variable and differ from one another. In some cases good plants are carefully operated, while in others they are neglected and incompetent men are employed, but the latter should not be taken as criteria for basing an award for damages.

It often happens that the power to be made up through the diversion of the stream is sufficiently small to be assumed by the existing engine. Of course, if this cannot carry the additional load another should be added, but if an expert seeks only to obtain the highest award for his client he will probably advocate an additional engine. The same remarks apply to boilers.

EFFICIENCY OF WATER WHEELS

The maximum efficiency of water wheels which are new and clean has been found to be nearly 85 per cent. Wheels are generally so made that the maximum efficiency is at 70 to 85 per cent. gate opening on account of the probability that the gate will not be wide open, as a general thing. Moreover, it is impossible to keep the wheels clean as they become rusty, coated with dirt and more or less clogged with débris. As the supply of water is variable and small at times, the usual position of the gate is likely to be at such a point that the average efficiency will not be over 75 per cent. The gate opening which corresponds to this efficiency is from 45 to 55 per cent.

Testimony is often given to the effect that the average efficiency of water wheels is as much as 80 per cent., and this is used in estimating the power loss, while an examination of efficiency curves and contemplation of conditions to which the wheels are subject will show that such an efficiency under the conditions is impossible.

Wood Pipe for Conveying Water—"How long will it last?" is a question asked perhaps more than any other concerning the use of wood pipe for irrigation. That the life of such wood pipe should be at least 20 years if the pipes are fully exposed and supported free from all contact with the soil; if the material is either fir or redwood; and if the pipe has been properly maintained, is the conclusion of a specialist of the U. S. Department of Agriculture in a professional paper on "Wood Pipe for Conveying Water for Irrigation" (Bulletin No. 155). Irrigation engineers and the owners of irrigation works will be particularly interested in this new pamphlet, which may be had free of charge by applying to the Department of Agriculture, Washington, D. C.

ENGINEERING AFFAIRS

Mountain States Ice Manufacturers Association—The second annual meeting of the Mountain States Ice Manufacturers Association will be held at the Albany Hotel, Denver, Colo., Thursday, Friday and Saturday, Jan. 21, 22 and 23, 1915. James F. Vandewark, Fort Collins, Colo., is secretary.

Y. M. C. A. School in Refrigeration—The West Side Y. M. C. A., 318 West 57th St., New York City, has decided to offer courses of instruction in refrigerating engineering. The special aim of these courses will be to meet the special requirements of the operating engineer, but if the demand warrants it, design courses will be included. Evening classes will be offered for engineers working during the day and day classes for men working at night. Prof. R. L. Shipman, recently of Cornell University, who has an extensive experience as operating engineer, will act as director of these courses.

PERSONALS

F. L. Bunton, for the past two and one-half years manager of the Chicago office of the Heine Boiler Co., is now manager of the Chicago office of the Goulds Manufacturing Co., 3801-3811 South Ashland Ave., Chicago, Ill.

Nicholas S. Hill, Jr., consulting hydraulic and sanitary engineer, 100 William Street, New York, has formed a partnership with Smith Farley Ferguson, and will continue to practice with him under the firm name of Nicholas S. Hill, Jr. and S. F. Ferguson. Mr. Ferguson will assume charge of the office management and the finances and accounts of the firm, as well as of the awarding of contracts and of the ordering, inspection and delivery of materials for construction work and contribute his experience in the design, erection and operation of steam power plants. For a number of years past he was president of Mackenzie, Quarrier & Ferguson, Inc., contracting and construction engineers.

Byron T. Burt has tendered his resignation to take effect Jan. 1, as general manager of the Chattanooga & Tennessee River Power Co., and he will be succeeded by George S. Baker, who has been auditor of the company. Mr. Burt will go to Buenos Aires early in the year as manager of the South American Trading Co., and will open the main office of that concern for the sale of American manufactures in Argentina. He was manager of the old Chattanooga Electric Co. until its consolidation with the Chattanooga Railway & Light Co. When the Chattanooga & Tennessee River Power Co. was organized to construct the power plant at Hale's Bar on the Tennessee River, he was made general manager. He is an electrical engineer and member of several national scientific organizations.

OBITUARY

COLONEL E. D. MEIER

Col. Edward Daniel Meier, eminent engineer and manufacturer, died at the home of his daughter in New York City, Dec. 15, in his 74th year. The immediate cause of death was heart failure and hardening of the arteries. Ill health had kept him from active participation in business for over a year. The funeral services were held from his home in St. Louis, Dec. 17.

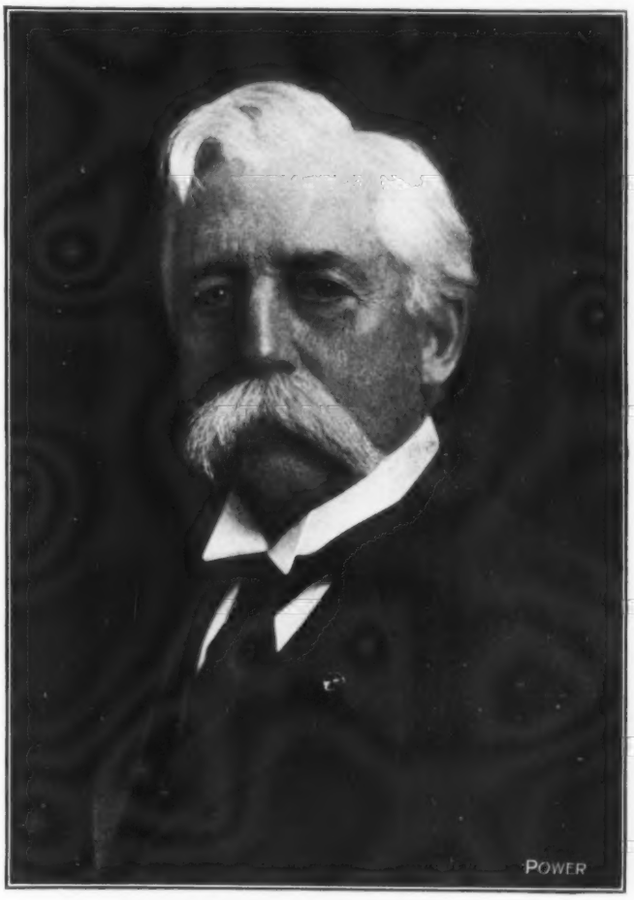
Colonel Meier was born May 30, 1841, in St. Louis, Mo., the son of Adolphus Meier, a prominent industrialist.

After a scientific course in Washington University, St. Louis, young Meier studied for four years at the Royal Polytechnic School, Hanover, Germany. In 1862 he started as an apprentice at the William Mason Machine Works, Taunton, Mass., but soon entered the army. Here he served in an engineering capacity and had the honor to receive the surrender of Lieutenant-General Hood. His colonelcy was acquired in the Missouri National Guard, following his activity in the railroad riots of 1877. He declined a commission as brigadier-general.

After the war Colonel Meier was for a year connected with the Rogers Locomotive Works, Paterson, N. J., and in 1867 was made assistant division superintendent on the Kansas Pacific R.R., later becoming superintendent of machinery. After his resignation in 1871, due to ill-health, he took an active part in various industrial enterprises, such as the coking of Big Muddy coals and the smelting of Iron Mountain ores. He was chief engineer of the Illinois Patent Coke Co. In 1872 he was manager of the Meier Iron Co. and built its blast furnaces. From 1873 to 1875 he directed the machinery department of the St. Louis Interstate Fair. During this time he was actively interested in the St. Louis cotton industry and designed machinery for baling cotton, first with the St. Louis Cotton Factory and then with the Peper Hydraulic Cotton Press.

About 1884 Colonel Meier organized the Heine Safety Boiler Co. for the development in the United States of the water-tube boiler of that name, and was its president and chief engineer until his death. He was also responsible for the introduction of the Diesel motor into the United States. He visited Germany in 1897 to investigate it, and until 1908 was engineer-in-chief and treasurer of the American Diesel Engine Co.

Colonel Meier was active in a number of professional



COLONEL E. D. MEIER

organizations. From 1881 to 1884 he was treasurer of the St. Louis Engineers' Club and president from 1889 to 1890. During the latter period he was also secretary of the American Boiler Manufacturers' Association. As chairman of the committee on materials, he is largely to be credited with both the first and second sets of standard specifications. In 1908 to 1909 he was president of the association and also of the Machinery and Metal Trades Association.

In the American Society of Mechanical Engineers, Colonel Meier was active on many committees and was twice its vice-president, serving his first term from 1898 to 1900, and beginning the second in 1910. He was elected president of the society for the year 1911.

As the seventieth birthday of Colonel Meier, retiring president of the society, occurred on Memorial Day, 1911, during the Pittsburgh meeting, a large number of the members united in a subscription and presented him an illuminated address of congratulation, and also asked his consent to give sittings for a portrait. The artist was Daniel J. Strain, vice-president of the Boston Art Club.

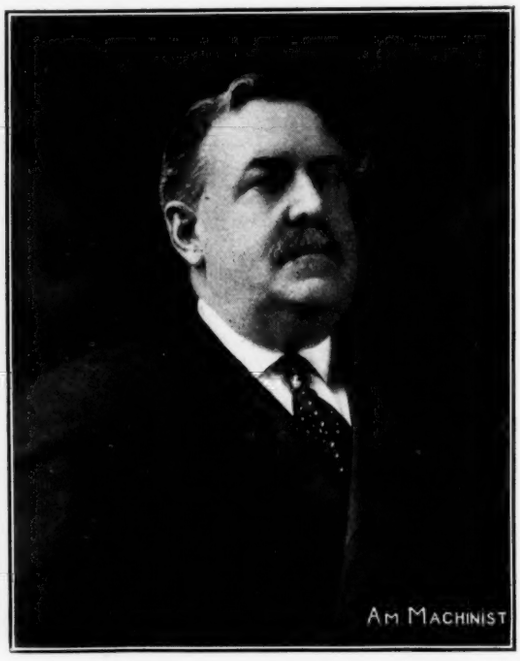
CHARLES A. MOORE

Charles A. Moore, president of Manning, Maxwell & Moore and a well known personality in the engineering supplies business, died of heart failure, on Dec. 9, on the Holland-American liner "Rotterdam" bound for Italy. Mrs. Moore was with him on the trip. Mr. Moore's health has been failing for the last few years and he has not actively managed the business during this time.

Mr. Moore was born in West Sparta, N. Y., in 1846 and was orphaned at the age of ten. He served in the Navy during the Civil War, after which he returned to Lynn, where he had been caring for an uncle.

In 1873, when the Ashcroft Manufacturing Co. was but a small hardware concern, Mr. Moore interested himself in the company and gave it considerable assistance. It was not long until Mr. Moore was active in several companies in New England, and his ability as a salesman and an organizer led him to create a world-wide selling organization devoted chiefly to steam specialties. In 1880 he came to New York and was active in forming the company of Manning, Maxwell & Moore. Late in the eighties Mr. Maxwell died and in 1905 Mr. Manning retired, Mr. Moore purchasing his share.

Mr. Moore was a member of the American Society of Mechanical Engineers and was for a long time a conspicuous figure in the Republican party. He was a noted Protectionist and was for some years president of the American Protective Tariff League. President McKinley and he were close friends, Mr. Moore accompanying him on several pleasure and campaign trips.



CHARLES A. MOORE

Mr. Moore was identified with the Shaw Electric Crane Co., the Consolidated Safety Valve Co., the Ashcroft Manufacturing Co., the Hancock Inspirator Co., and the United Injector Co.

CHARLES A. HOPPER

The announcement of the death of Charles A. Hopper, of the Keystone Lubricating Co., of Philadelphia, which occurred on Nov. 29, will be received by his host of friends with keen sorrow.

"Charley" Hopper was possessed of those characteristics which radiated good nature and unconsciously left their imprint upon those fortunate enough to know him. He was broad minded, capable and endeared himself to all.

He became associated with the Keystone Lubricating Co. soon after its organization by A. C. Buzby, the present general manager, and together they labored zealously to bring it to its present-day success. Being closely associated, it was but natural that Charley's opinion and judgment should be courted, and the loss created by his death seems irreparable.

Having a capacity for administrative salesmanship, he took up that department of the business which included steam engineering, power plants and mills. He was remarkably successful along these lines, and was personally known to many identified with these industries. Most of these acquaintances became fast friends and will mourn his death. Having reached an age which brought with it wide experience, much knowledge and an appreciation of life's demands, it was expected by those associated with him in his work that many years of usefulness would be his lot. Realization of the loss of a friend will be more poignant to those who will miss daily his inspiring presence.

"CHARLEY" HOPPER

He was a member of the National Association of Stationary Engineers and various societies, among them the Red Men, I. O. of A. and the A. O. U. W.

BUSINESS ITEMS

The Jeffery-Griner Machinery Co., Bourse Building, Philadelphia, Penn., has completed arrangements for handling the Neemes Bros. (Troy, N. Y.) grates in the Philadelphia territory.

J. H. Dougherty, formerly with the Engineering Department of the Jeanesville Iron Works, of Hazleton, Penn., has joined the staff of the Northern Equipment Co., Erie, Penn., in the capacity of designing engineer.

In order to properly handle business in the central district, the Power Specialty Co., 111 Broadway, New York, has found it necessary to move its Chicago office from Peoples Gas Building into more commodious quarters in the Harris Trust Building.

Betson Plastic Fire Brick Co., Rome, N. Y., is moving into a much larger plant, with increased facilities, in order to take care of its continually growing business, and after Dec. 1 will be located at 244-246 E. Dominick St., Rome, N. Y. The post office address is box 312.

Orr & Sembower, Inc., Reading, Penn., manufacturers of vertical, horizontal, marine and hoisting steam engines, vertical, horizontal and locomotive boilers and vertical, horizontal and hoisting gasoline engines, have opened a permanent exhibition in the Bourse, Philadelphia, Penn.

The Hunter Fan & Motor Co., of Fulton, N. Y., has sold its controlling interest in the Kitts Manufacturing Co., Oswego, N. Y., to Marvin E. King and James Parker, manager and superintendent of the Kitts Manufacturing Co. Messrs. King and Parker will continue along the same lines of manufacturing and will broaden the line to the extent of vacuum heating engineering work.

The Stephens-Adamson Manufacturing Co., Aurora, Ill., is changing the electrical equipment throughout its shops, using individual motors and group drives. Tests have been made on all machines, and the results assure a considerable saving in power cost. Plans are also being prepared for another structural steel shop; construction of the same to be begun immediately after the first of the year. This will be the eighth building of the company's plant. This company reports a very satisfactory increase in its business during the present year and a most encouraging outlook.